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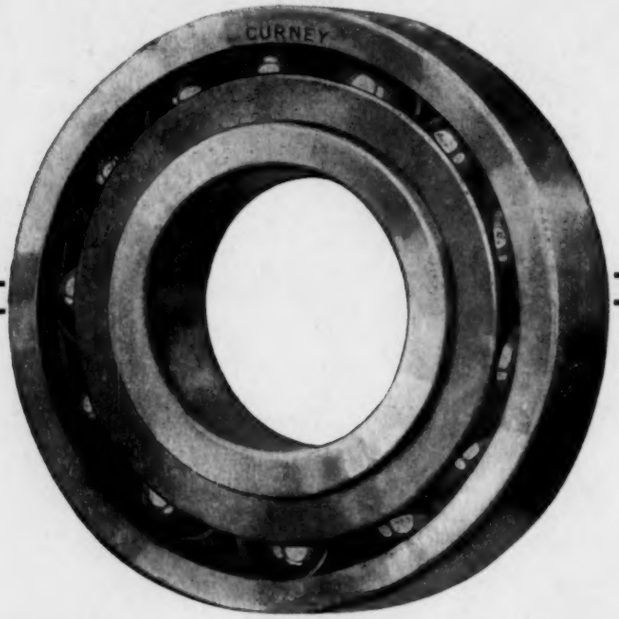

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GURNEY

Central-Station Heating in Detroit

By J. H. WALKER,[1] DETROIT, MICH.

This paper discusses the general problem of the utilization of the heat ordinarily discharged to the condensing water in a central electric generating station. The impossibility of its complete utilization for the purpose of heating buildings and the difficulties in the way of even its partial utilization are pointed out, with particular reference to conditions existing in Detroit.

The development of the central heating system of the Detroit Edison Company is traced, showing how the use of exhaust steam for heating was abandoned in favor of live steam. The reasons why it is more commercially expedient under the existing local conditions to supply live steam to the heating system and to generate all electric current in the condensing stations, are also fully brought out.

The latter part of the paper describes some interesting features of the central heating system in Detroit, such as the boiler plants, distributing system, underground construction of pipes and tunnels, consumers' installations and meters. Special mention is also made of the method of transmitting steam through feeders at high velocities and with large pressure drops.

The complete paper concludes with a discussion of the advantages of central heating service and of the obstacles to its wider use. It also points out the possibility of operating individual plants in combination with the central plant.

ONE of the natural results of the grouping together of human beings, in civilized communities is the existence, in our cities, of central plants for the generation and distribution of heat to surrounding buildings. The advantages of central heating service to the user, over the alternative of operating a heating plant in his own building are comparable to those accompanying any other public service. To the community, also, a properly operated central heating plant is a distinct asset, commercially and economically.

Started in a limited way about forty years ago, the central heating industry has grown steadily, though not with the rapidity of some other utilities, until at the present time there are between two and three hundred enterprises operating as public utilities in cities of all sizes in most of the northern states and doing an annual gross business estimated at from ten to fifteen million dollars. The capital invested is perhaps thirty to forty million dollars. As media for distributing the heat both hot water and steam are used, but because of the impracticability of metering hot water and because of the greater adaptability of steam to the requirements of the average building the trend of progress is toward the later. Further development of the business now hinges mainly upon the possibility of the establishment of the proper relationship between rates and the cost of service so as to insure adequate return upon invested capital. In many instances this relationship is not satisfactory at present, chiefly because the actual cost and the value of the service are not known. The engineering practicability has been amply demonstrated; and that there is a pronounced economic demand for the service is beyond question.

The central heating business is closely allied with the electricity supply business and in most cities is carried on directly or indirectly by the electricity supply companies. The task of supplying the demand for heating service falls quite naturally to the electric company because of the partial similarity in the methods of production and distribution of the two commodities; and because the ability to offer to its prospective customers both electric and heating service, with the consequent entire elimination of any sort of power plant from the customer's building, is of great advantage to an electric company doing business in a large city.

Other reasons for the combining of the two utilities are the economies in the consumption of fuel, and to some extent in the investment costs, which are sometimes made possible by the physical combination of the electric and heating plants.

The heat carried away by the condensing water in the central electric stations of the United States, equivalent to about 60 per cent of the total fuel burned by them, is one of the more obvious, although not by any means the greatest, wastes of the country's resources. Like many other similar losses this one exists, not because its reduction is theoretically impossible but because it is seldom commercially practicable. But although commercial considerations have always dictated certain practices in the utilization of fuel and will continue to do so in the future, the increasing cost

FIG. 1 WILLIS AVENUE CENTRAL HEATING PLANT

of coal and the present impulse toward its conservation now direct attention to some of the fundamental problems involved.

This great quantity of heat, rejected at low temperature from the generating units, may be considered as a by-product of electricity supply and as such its rate of production will depend upon the rate of production of electricity, the primary product. The complete utilization of any by-product becomes possible only when an outlet for it exists or can be created. Moreover, since neither electrical energy nor heat can be stored to any great extent, it is necessary for the complete recovery of this by-product that the demand for it be equivalent, hour by hour, and day by day, to the rate of electricity supply. The warming of the interior of buildings is of course a natural means of utilizing this heat, but the great diversity in the rate of use of the two commodities renders impossible even an approximately complete realization of the theoretical economy. The lack of agreement in their use from week to week throughout the year is illustrated in Fig. 2, in which the 1918 load curves for electrical and heating service in Detroit are plotted to a percentage scale with the maximum point on each curve taken as 100 per cent.

The possibility of establishing a better relation between the rates of use is rather slight. The rate of heat supply is largely

[1] With Detroit Edison Company, Detroit, Mich.

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fixed by unalterable climatic conditions. The use of electricity for lighting is also governed by natural elements. The demand for electricity for industrial use, which now constitutes a major fraction of the output of most central stations is not governed by these factors, and is the only kind of load whose characteristics could conceivably be adjusted to suit the requirements for exhaust heat and even this could probably not be done to any practicable extent.

Another important obstacle to the full use of this by-product heat through the warming of buildings is due to the great development of the central electric stations which in many industrial centers in the United States have so increased in size that the amount of exhaust heat which would be available as a by-product is greatly in excess of that which it would be commercially feasible to distribute

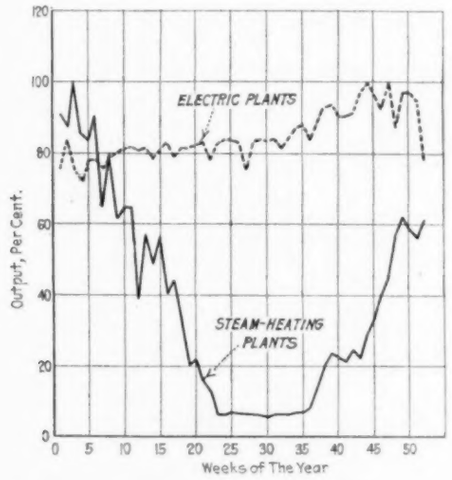

FIG. 2 LOAD CURVES OF ELECTRIC AND STEAM-HEATING PLANTS

for the heating of buildings. For example, in 1918, the central electric-generating stations in Detroit produced approximately 774,000,000 kw.-hr. of electricity. The exhaust steam which would have been available if discharged at pressures above atmosphere and which could have been utilized for heating, considering the winter months only, would have amounted to over 9,000,000,000 lb. This is five times the quantity actually distributed in the existing central heating system of the city, which entirely covers the only portion of the city in which the heating load is sufficiently dense to render the laying of distribution mains commercially justifiable. For because of the great investment costs the distribution of heat by the medium of steam is feasible only in the districts of relatively great density of load, which, in most of our cities, comprise only the business district and the very best residence districts. Nor are the economies to be gained by using by-product heat sufficient to enlarge this area appreciably. The central heating business in the average American city could keep pace with the electricity supply business only if the density of population were far greater than is compatible with present standards of living.

Thus it is apparent that the exhaust heat from central electric stations can at best be utilized for heating only during the times when heat is required and then only in so far as it can be commercially distributed. But there are certain obstacles which stand in the way of its utilization even to this extent—obstacles which arise primarily from the difficulty of transmitting steam over long distances.

SYSTEMS OF CENTRAL HEATING

Assuming that a central heating load exists and is to be supplied by the electric company, there are in general three methods by which this can be done:

1 The heating load can be served from a condensing generating station so designed that steam is available for heating at pressures above atmosphere after partial expansion in the electric-generating units, the remainder of the steam used for current generation being fully expanded and condensed at high vacuum.

2 Separate heating plants may be built in locations near the heating load and equipped with non-condensing generating units which will generate current only to the extent of the requirements for exhaust steam for heating, the remainder of the electricity being produced in a condensing station.

3 The heating system may be supplied entirely with live steam from boiler plants located near the center of the heating load.

It may so happen that the natural location for the main generating station serving a city is near the heating load, and if this is the case, the first method is preferable. Often, however, a consideration of land values or of railroad connections requires that the main condensing station be located at such a distance from the heating load as to preclude the possibility of transmitting steam from it. This is the case in Detroit. The Delray plant and the Connors Creek plant, the two main generating stations operated by The Detroit Edison Company, are respectively 3½ and 4½ miles from the heating district. A condensing plant, located on high-priced land near the heating district and with inconvenient railroad connections, or none, would be necessary if this first method were to be used. To such a plant, built for electricity supply and consequently, for reasons previously stated, burning more coal than a plant built solely for heating, this matter of proper railroad facilities is particularly important. Here again enters the matter of the transmission of steam, for the size of the pipes required to transmit a given quantity of steam over a given distance decreases as the density of the steam and the amount of pressure drop along the pipe increase. The most economical method from the standpoint of investment costs would

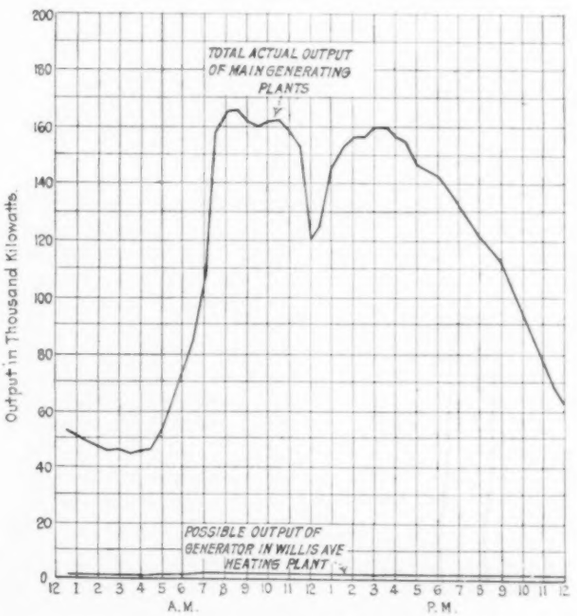

FIG. 3 LOAD CURVES SHOWING POSSIBLE ELECTRIC OUTPUT OF HEATING PLANT AS COMPARED WITH OUTPUT OF MAIN STATION

be to extract steam from the high-pressure stages of the turbine; but the amount of electricity which could be generated per pound of steam would then be reduced.

In Detroit many of these conditions conspire to make the use of exhaust steam for heating unattractive. Generating units exhausting into the heating mains were operated in one of the heating plants for several years, but this practice has since been definitely abandoned and the heating system is now being supplied with live steam. Current generation is limited to the output of small house-service turbo-generators whose exhaust is utilized to heat the feedwater. The history of the central heating industry in Detroit is one of steady progress toward this method of live-steam operation.

DEVELOPMENT OF CENTRAL HEATING IN DETROIT

The immediate motive which, in 1903, led to the establishment of the central heating industry in Detroit was the possibility of obtaining a high thermal efficiency in the generation of electricity through the utilization of the exhaust steam. The generating plant from which steam was first supplied for heating had previously discharged its exhaust to the atmosphere. Owing to the building, at this time, by The Detroit Edison Company, of a large condensing plant, the smaller plant, with several others, would have been shut down, but the possibility of selling the exhaust steam made it appear desirable to continue the generation of current there to the extent of the exhaust-steam requirements. Also, since the plant was located in a district served with direct current the loss involved in converting an equivalent amount of alternating current received from the main plant to direct current would be saved for such current as might be generated there. The plant was in a high-class residence district and the heating service proved very popular, but the actual overall economy of the plant was not as great as had been anticipated.

A year later the construction of a central heating plant was begun in the business district of the city. This second project was undertaken, not as a means of disposing of exhaust steam, but for the express purpose of supplying the demand for central heating service among the owners of downtown buildings who were considering shutting down their plants and purchasing electric service. The downtown plant was built primarily as a heating plant and though provision was made for electric generating units they were never installed and the heating mains were supplied with steam from the boilers through reducing valves.

With the development of the large condensing generating stations the generation of current in the heating plants grew less and less attractive and when a third heating plant became necessary because of increasing demand for steam heat no provision was made for electric generators. The same practice was followed when, in 1916, the original exhaust-steam plant was rebuilt; and when the steam distribution system of another company which had been engaged in the generation of electricity and the distribution of exhaust steam in the business district was purchased by The Detroit Edison Company the new plant which was built to supply this district was also designed as a heating plant only. The entire combined distribution system is now being supplied with live steam from the boilers through reducing valves.

Since there are no generating units exhausting into the heating system the pressure carried on it is not limited by considerations of back pressure. On those sections of the system formerly supplied with exhaust steam at from 2 to 5 lb. pressure, the pressure now maintained ranges from 5 to 15 lb. and is being increased from year to year, toward the upper limit permitted by the strength of the pipes. The pressure on the section originally designed as a live-steam system is about 30 lb. Because of the increased capacity of the distribution system at higher pressures, due to the greater density of the steam and the greater allowable pressure drop, these higher distribution pressures are desirable.

The steam is delivered to the network of mains through connections made at the plants and also through feeders, from the plants which deliver steam to certain feeding points in the distribution network, the method being similar to the feeder and main method employed in electric distribution systems.

REASONS FOR USING LIVE STEAM IN DETROIT

The supplying of live steam to the heating system and the abandonment of the generation of current in the heating plants is commercially justifiable, even though such current would be generated at a high thermal efficiency. The underlying reason for this is that there exist certain unfavorable conditions which outweigh the thermal advantage and make the total cost of such current higher than the generating cost at the large and efficient main generating stations.

In considering the cost of generating current, when the heat in the exhaust is recovered, it should be borne in mind at the outset that the amount of coal consumed, though small, is not by any means negligible as compared to that consumed in a condensing station. For each kw-hr. so generated, there would be extracted from the steam, if the conversion were 100 per cent efficient, its heat equivalent 3415 B.t.u. Taking into account mechanical and electrical losses in the generating unit and the losses involved in generating steam from the coal, the actual number of heat units devoted to the generation of electricity is not less than 5700 B.t.u. per kw-hr. This is 27 per cent of the corresponding figure for the Connors Creek plant (a condensing station) which in 1918 generated its total output at an average of 20,900 B.t.u. in the coal per kw-hr. of output. So that at the outset, the additional fuel which would have to be burned in the heating plants if current were generated, would be over one-quarter of the amount required to produce the equivalent amount of current at the Connors Creek plant.

One of the principal elements of cost which militates against current generation in the heating plants is the attendant labor, which, because of the low load factor and small size of any generating units which might be installed there, makes the cost of this item per kw-hr. generated much higher than in the large stations where the size of the units and the load factor are much greater.

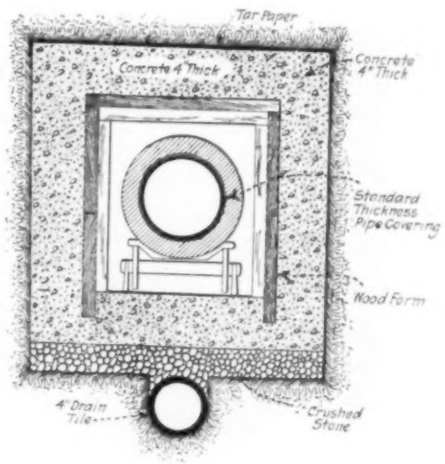

FIG. 4 UNDERGROUND STEAM-LINE CONSTRUCTION

But the deciding factors are the investment charges. The change of policy involving the final abandonment of exhaust steam heating was made in 1916, with the rebuilding of the Willis Avenue heating plant, the original exhaust-steam plant. At this time the electrical load in Detroit was increasing rapidly and several new turbine-generator units were being purchased. At the Willis Avenue heating plant the existing and future exhaust steam requirements would have called for a generating unit of about 2000 kw. capacity. The unit purchased at the time for the Connors Creek plant was the 45,000-kw. machine which has since been put into service. Would the existence of small generating units in the heating plants, aggregating altogether possibly 4000 kw., actually reduce the number of machines in the Connors Creek plant at that time or at any future time, if the latter were to increase in steps of this magnitude? Regardless of theoretical considerations, as a matter of fact it actually would not have done so and it became clearly evident, therefore, that any investment in generating units in the heating plants must be reckoned as *additional* investment and the cost of any electricity generated by them must include the fixed charges on that investment and could not be credited with having saved any investment elsewhere. The relatively insignificant proportion of the total system load which could be born by a unit in the Willis Avenue plant is strikingly illustrated in Fig. 3.

The small size of the unit and its low load factor would make

these investment charges relatively high per kw-hr. generated. Furthermore, while the chief advantage of the heating plant generating units would lie in their ability to avoid conversion losses by generating direct current required for the downtown district, this advantage could not be completely made use of because of the lack of coördination between the heating and electrical loads of that district, which would make it necessary to convert some of the direct current back to alternating current for transmission to some other district or else would reduce the load factor of the unit.

For a quantitative economic study of the subject the Willis Avenue heating plant offers a favorable example, for it had been operated as a generating plant and the distribution mains had been designed for exhaust-steam pressures. Based on the performance of the old engine-driven units there would have been generated about 6,000,000 kw-hr. per year.

In accordance with the considerations which have been mentioned, the proposed turbo-generator installation should be

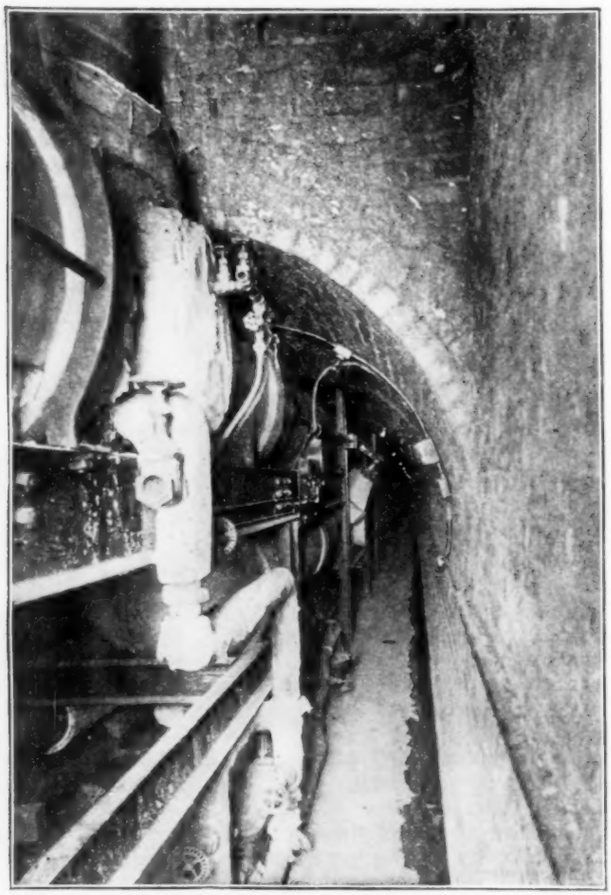

FIG. 5 TUNNEL CONSTRUCTION FOR STEAM LINES

charged with its operating and maintenance costs including, labor, supplies, and the fuel equivalent of the energy produced. It should also be charged with the fixed charges on the unit itself and on the building space occupied. Based on the fairly stable pre-war prices existing in 1916, these items might be conservatively estimated as follows, neglecting the disadvantage due to the lack of coördination between steam and electrical loads.

Charges Against Generating Unit—Operation and Maintenance:	
Labor—3 oilers	$3,360
Supplies, etc.	200
Fuel cost—1221 tons at $2.66	3,247
Maintenance	200
	$7,007

Fixed Charges (Additional Items Only):	
2000-kw. turbo-generator at $15 per kw.	$30,000
Installation cost, wiring and piping	4,000
Building and foundations	10,000
	$44,000
Depreciation at 4 per cent	1,760
Return on investment at 6½ per cent	2,860
Total charge against turbine	$11,627

The turbo-generator must of course be credited with the cost of generating an equivalent amount of energy at the main plant, of transmitting it to the heating plant district, and of converting it to direct current, since these costs would be incurred if the turbo-generator were not installed.

The production cost of electric current generated by a central station consists of two parts, the demand or "readiness to serve" component and the "energy" component. The former may be defined as that portion of the total production cost which would be incurred if no electricity were actually delivered, but if the plant were merely held in readiness to deliver the loads actually sustained, in other words, with steam pressure up, turbines and auxiliaries in motion, a sufficient number of boilers banked and the operating crew on duty. The energy component may be considered as that part of the total cost which is directly proportional to the amount of energy delivered. Although the exact separation of these components is impossible, the distinction between them is none the less real and is one that is generally recognized.

In the present case the heating-plant generating unit can be credited only with energy component, since it is not to be considered as having reduced the size or number of units in the main generating plant. The energy component may fairly be considered as including 75 per cent of the fuel cost, 50 per cent of the cost of maintenance of plant equipment and that part of the labor such as coal handling which may be considered as depending upon the amount of electricity generated, and amounting in this case to 9 per cent.

The actual combined efficiency of transmission to the heating plant district and of conversion to direct current is approximately 80 per cent, so that to deliver 6,000,000 kw-hr. of direct current to the heating plant district there would be generated at Connors Creek 7,500,000 kw-hr.

The credit which can be allowed to the heating plant for the current which it would generate would then be as follows:

Fuel—4112 tons at $2.38	$9,786
Wages	285
Maintenance	617
Total credit allowable	$10,688

This credit of $10,688 compared with the larger figure of $11,627 which is to be charged against the heating-plant unit, thus indicates that the generating of current in the heating plant would not be justified.

The foregoing study, however, is based only upon conditions in the plant itself and no mention has been made of the effect upon the distribution system when exhaust steam is distributed. It is common practice in exhaust-steam systems to carry a back pressure of from 2 to 15 lb. At these pressures the specific volume of the steam is high and the allowable pressure gradient throughout the system is very limited, making it necessary to install much larger pipes than is the case when live steam at higher pressures is used and consequently increasing the investment. While it is true that turbines have been built for exhaust pressures up to 30 lb., the electrical energy which can be extracted per pound of steam under such conditions is reduced and the cost per kilowatt of turbine capacity is increased; furthermore, in the method of feeder operation which is actually employed and which has proved of inestimable value, the pressure of delivery to the feeders is much higher than this.

The method of live-steam operation was adopted in Detroit before the recent great advance in the price of coal. The present high price of coal makes exhaust-steam operation appear somewhat more favorable and it is of course conceivable that at

some future date a very high coal price may compel a change of policy. But with the cost of underground lines also increasing, the saving in distribution investment will probably continue to be sufficient to justify a continuation of the present methods.

Most of the foregoing facts only apply in cases where the generating capacity in the heating plant is negligible in comparison with the main generating stations. If this is not the case, if the discrepancy in size is not great so that investment in the main plants is actually saved, or if the additional current required from the condensing station is actually not produced at a relatively low cost, then the situation may be entirely changed, and there are many instances of this in the United States. The consideration of the steam-transmission investment when low-pressure steam is used is usually controlling, however, and is being increasingly well recognized.

Boiler Plants

The four boiler plants in Detroit which supply steam to the heating system are equipped with water-tube boilers and underfeed stokers and are of modern design throughout. Their location in the central district of the city necessarily restricts the amount of land which they may occupy and demands a suitable type of architecture, absolutely smokeless operation, and extreme cleanliness in the handling of coal and ashes. Fig. 1 shows how these ideas have been carried out in the Willis Avenue plant.

The Congress Street plant, the newest of the four, is designed to eventually contain four 1300-hp. boilers and two 2600-hp. boilers of the "W" type. In the effort to reduce the amount of attendance labor at this plant the auxiliaries are located, for the most part, on the boiler-room floor so as to be within convenient reach of the few men constituting the operating crew. Coal is hauled from bunkers at the railroad sidings to the plant in drop-bottom buckets of 5 tons capacity, which are lifted by a crane and emptied into overhead hoppers from which the coal is distributed by belt conveyors to the boiler bunkers. Ash-handling equipment is practically nil, the boilers being set at sufficient elevation to allow wagons to be driven beneath the hoppers.

Because of the fact that only a relatively small amount of condensation is returned to the plants, careful treatment of the raw water is necessary. The feedwater flows through live-steam purifiers, operating at boiler pressure, in which the scale-forming materials are precipitated. In addition, sodium carbonate is fed in automatically graduated amounts to reduce the slight amount of hard scale-forming material which finds its way into the boiler. Although Detroit water is not a bad boiler water, these precautions are necessary because of the large percentage of make-up water and the rather high rates of steaming at which the boilers are sometimes driven.

The auxiliaries are almost entirely motor-driven. The current is supplied by a 750-kw. turbo-generator unit exhausting into an open feedwater heater. The load carried on this generator is adjusted according to the requirements for exhaust steam for heating the feedwater and any excess current generated is delivered to the outside electric-distribution system. Conversely, if the electricity requirements of the plant exceed the output of the generator, current is drawn from the outside supply. Exhaust steam is thus made available for heating the feedwater and the advantages of motor-driven auxiliaries are also secured. Moreover the turbo-generator constitutes a source of electricity supply for the plant in case of local interruption of the outside service.

Steam is generated at a pressure of 130 lb. gage. This pressure is chosen in order to provide for considerable pressure drops in the outgoing feeders as calculated for present conditions. It may be raised to 160 lb. at some future date. The outgoing steam lines leave the plant through a tunnel shaft.

Distribution System

The popularity of the heating service in Detroit has led to its development on an extensive scale. The present distribution system covers an area of about 2 miles long and half a mile wide which includes the entire central shopping, business, and financial districts and a small portion of the residence district. About 2,700,000 sq. ft. of radiation, besides numerous water heaters and cooking fixtures, are served. The distribution system contains about 20 miles of underground mains and 2 miles of tunnels. The four boiler plants which supply steam to the system contain 17,470 rated boiler hp., and they delivered in 1918 nearly two million pounds of steam to the system. Over 1700 consumers are served.

The distribution mains, though originally built in three distinct sections, are now a practically continuous network and the plants are so much interconnected that the load can readily be shifted from one to another. In spring and early autumn two of the four plants serve the entire area.

Because of the great increase in connected load the transmission capacity of the distribution network, most of which was installed several years ago, is now quite inadequate. To have raised the pressure throughout the system would have increased its capacity; but the system pressure was permanently limited

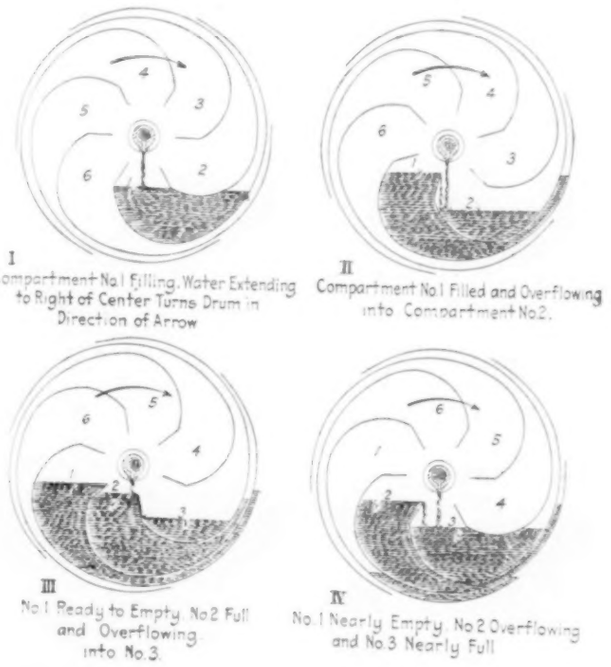
I
Compartment No.1 Filling, Water Extending to Right of Center Turns Drum in Direction of Arrow
II
Compartment No.1 Filled and Overflowing into Compartment No.2.
III
No.1 Ready to Empty, No.2 Full and Overflowing into No.3.
IV
No.1 Nearly Empty, No.2 Overflowing and No.3 Nearly Full

Fig. 6 Condensation Meter and Its Principle of Operation

by the fact that most of the underground fittings are of a low-pressure pattern, and temporarily by the fact that in those sections of the system formerly supplied with exhaust steam the customers' installations are not provided with reducing valves. Instead of attempting to change these conditions, which would have involved the reconstruction of much of the distribution network, the less expensive plan was adopted of running feeders from the plants to various centers of distribution. In selecting the pipe sizes for feeders, advantage is taken of the difference between boiler pressure and distribution pressure, and the size of the pipe is so chosen that at times of maximum load much or even all of this pressure drop will take place in the pipe itself. The diameter and the cost of the pipe line are thus materially reduced. In operation, the pressure of the steam delivered to the feeder is raised or lowered as required by the adjustment of a reducing valve at the plant, in order to maintain a constant pressure at the center of distribution which the feeder supplied. The pressure existing at this center of distribution is recorded at the plant by a long-distance gage, electrically operated.

The velocity of the steam flow in feeders at times of heavy load is very high. Velocities as great at 75,000 ft. per min. have

been measured. This high velocity does not appear to be at all objectionable, however, there being no apparent erosion of the pipe and no hammer, or objectionable vibration. The fact that the steam is in a superheated state because of the pressure drop is an advantage in these respects. Feeders are constructed with long radius bends and where the connection is made to the distribution mains the diameter of the pipe is gradually increased by special taper fittings so as to reconvert a portion of the velocity head to static pressure.

A considerable pressure gradient is also allowed to take place in the distribution mains as well as in the feeders; but this is relatively small, since the upper limit is fixed by the allowable working pressure of the older mains. The more recently laid mains are capable of withstanding a working pressure of 125 lb.

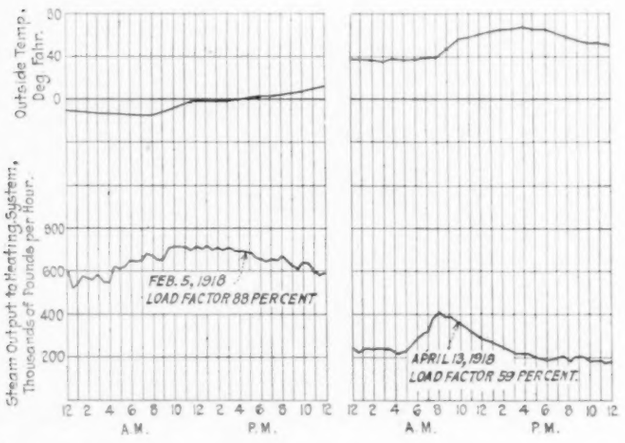
Outside Temp., Deg. Fahr.
Steam Output to Heating System, Thousands of Pounds per Hour.
FEB. 5, 1918
LOAD FACTOR 88 PER CENT.
APRIL 13, 1918
LOAD FACTOR 59 PER CENT.
A.M.
P.M.

FIG. 7 TYPICAL LOAD CURVES OF HEATING SYSTEM

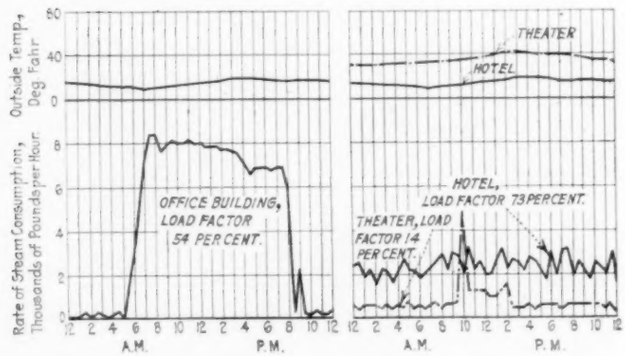
Outside Temp., Deg. Fahr.
Rate of Steam Consumption, Thousands of Pounds per Hour.
THEATER
HOTEL
OFFICE BUILDING, LOAD FACTOR 54 PER CENT.
HOTEL, LOAD FACTOR 73 PER CENT.
THEATER, LOAD FACTOR 14 PER CENT.
A.M.
P.M.

FIG. 8 TYPICAL LOAD CURVES OF INDIVIDUAL CONSUMERS

and the gradient in the mains can therefore be increased at some future date. From a standpoint of safety, however, the desirability of carrying pressures in excess of about 50 lb. on the service connections to buildings is questionable until further development in pressure-reducing apparatus is made.

This method of steam distribution is obviously an adaptation to previously existing conditions and would doubtless be modified if an entirely new system were being laid out.

UNDERGROUND CONSTRUCTION

The distribution mains range in size from 20 in. near the stations to 4 in. at the outskirts of the system. The original underground pipes were laid in a segmental wood casing bound with wire. This construction has been fairly successful under favorable soil conditions, but the concrete conduit shown in Fig. 4 has been found to be superior in many respects and has been used exclusively for several years in all new construction. In this construction the pipe is insulated with a standard thickness of pipe covering and surrounded with an envelope of concrete poured over a wooden form, leaving an air space around the pipe. Proper underdrainage is of course essential.

The longitudinal expansion and contraction of the pipe, due to changes in its temperature, are absorbed, in the earlier construction, by means of expansion fittings of the copper-diaphragm type. In recent construction a slip joint, consisting of a brass sleeve, sliding in a packed gland, has been used. The use of slip joints decreases somewhat the cost of the pipe line as they will absorb more travel and can be placed at wider intervals than the diaphragm fitting.

The underground mains have not been laid sufficiently long to permit of an accurate estimate of their life. The oldest lines laid in wood casing have now been in service 15 years and, while the casing in many places has deteriorated considerably, in other places it is in fairly good condition. The concrete construction, dating back 10 years, seems to have deteriorated very little. The only repairs or replacements which have been made to date have been made necessary by external corrosion or pipe arising from some outside and local cause such as a water-pipe leak. An average life of 20 years for the wood-log construction and 30 years for the concrete construction would seem to be a very conservative estimate. Soil conditions in that part of the city where the heating mains are laid are particularly favorable, the soil being very well drained.

Manholes are located at intervals of about one city block (300 to 400 ft.), to house the slip joints, valves, and bleeder traps.

In the heart of the business district the pipes are in tunnels, of which there are about 2 miles, lying from 25 to 40 ft. below the street level. In cross-section they are similar to a horseshoe and are built of brick, with concrete floors. (Fig. 5.) For the most part they are about 6 ft. in height and 6 ft. wide. The tunnels are ventilated by suction fans which draw a small amount of air through them continuously and much larger amount when it becomes necessary for men to work in the tunnels. Their temperature ranges between 90 and 130 deg. fahr. When two of more pipes are to be laid under a street in a congested district it has proved desirable to build a tunnel to avoid the inconvenience to the public attendant upon tearing up the street, either for the original construction work or for subsequent changes. The tunnel permits of ready access to the pipes at any time, and since it is far below any other structures, no obstructions are met with. Tunnel construction is exceptionally simple in Detroit where the subsoil is a blue clay nearly impervious to water and well adapted to tunneling operations. The cost of tunnel construction is high but the advantages gained are compensatory.

CONSUMERS' INSTALLATIONS

The consumer's equipment includes, besides the usual radiators and piping, a pressure-reducing valve, which reduces the service pressure to the lower pressure required for heating, and a trap whose function is to discharge the water of condensation from the system.

Any existing steam-heating system can be adapted for service by making a few minor changes. A hot-water system can be served with steam by substituting for the fuel-burning water heater a surface heater in which the water in the system is heated by the steam. A hot-air system can be adapted to the use of steam by substituting steam coils for the furnace and using the same duct system, though this is rarely done.

Economizer coils, utilizing the heat in the condensation, are recommended by the Company but not required. They are seldom installed in any but the largest buildings as few consumers see fit to make the necessary investment even though a demonstrated saving can be made. In some buildings the condensation is passed through a surface heater which preheats the water used for lavatory purposes, and this seems to be the most satisfactory form of economizer for large buildings.

The consumer's installation is the least reliable factor in the maintenance of uninterrupted and satisfactory service. Boiler plants can be and are designed and operated so as to be extremely

reliable. A distribution system, if properly laid out, with ample capacity and duplicate feeding routes, can be operated so that the steam supply to a building is practically never interrupted. But the consumer's piping system and the special appliances attached to it, operated by persons unfamiliar with mechanical apparatus, are a frequent source of trouble. Tagging of the valves to indicate their proper operation, distribution of printed instructions and other educational measures are employed with varying success, and the service is on the whole much more reliable than that obtained from the ordinary individual plant. A "trouble service" is maintained day and night to insure immediate attention to minor repairs and adjustments of consumers' equipment.

The regular heating season covers 8 months of the year, though summer service for cooking and water heating is supplied to a few consumers conveniently located. Cool weather in September usually makes necessary the commencement of service before the contract date of October 1. It has, in fact, been started in August. Steam was originally sold to some extent for power purposes but this service is now practically discontinued.

METERS

With the exception of a number of calibrated steam jets used in cooking fixtures, the steam is sold entirely on a condensation basis, the condensation flowing from the system through a meter and thence to the Company's return line or to the sewer.

The art of metering condensation was comparatively new when the Company commenced operations and although many advances have been made, it has not yet reached, and probably never will reach, the standards of reliability and accuracy of electrical metering. The troubles experienced are largely mechanical; but there are certain fundamental obstacles in the way of their entire elimination. The operating conditions, because of excessive temperatures, moisture, and dirt, are severe, and the allowable size and cost of the meter are limited.

The meter first used in Detroit was of the tilting type, consisting of a rectangular pan of two compartments hung on knife-edge or ball bearings, the compartments filling alternately and, when full, tipping the pan so as to bring the opposite compartment to the filling position. In 1907 a revolving meter was devised, consisting of a drum of four compartments which filled and dumped successively, the drum being revolved by the weight of the water. This meter was fairly successful and a few of that design are still in use, but a greatly improved design of revolving meter, operating on the same general principle, (Fig. 6) was originated in 1909 by Hans Resert and is being used at present, with slight modifications.

LOAD CHARACTERISTICS

The daily boiler-plant load curves vary considerably both in magnitude and in shape with different outdoor temperatures. In moderate weather steam is used in many buildings only for a few hours in the morning, resulting in a decided peak at that time with a steady decrease in load throughout the remainder of the day. On the very coldest days, however, the heat is used continuously throughout the 24 hours, in most buildings, giving a daily load factor on such days of between 85 and 95 per cent. This is illustrated in Fig. 7. The monthly sales of steam are very closely proportional to the difference between 70 deg. fahr. and the average outside temperature. The annual load factor is about 35 per cent.

The load curves of the individual buildings show these same general characteristics although different types of buildings have markedly different daily load curves. In Fig. 8 are shown the load curves of three buildings of different types. The high peak, in the case of the theater was caused by the throwing on of the fan system. The steam in the office building was shut off at night, while in the hotel it was used continuously.

Detroit rates at the present time take no account of varying load factor, though this is done in some other cities in an approximate way. Possibly future progress in the art of metering will lead to the general establishment of rate schedules having a demand component as well as a consumption charge.

Fire Engines and Effective Fire Fighting

By CHARLES H. FOX,[1] CINCINNATI, OHIO

The importance of the fire engine and the methods employed in fire fighting are frequently underestimated by both layman and engineer, and this is due in no small part to the fact that the principles involved are not sufficiently understood. In this paper the author presents the essentials of effective fire fighting and shows the important relation thereto of the fire engine.

A brief historical sketch of the development of the fire engine is first given, and performances and methods of rating fire engines, as outlined by the National Board of Fire Underwriters, are next presented. The paper concludes with a discussion of the losses in fire hose and the design of nozzle areas.

STEAM power was not successfully applied to fire engines until the beginning of the year 1853. Up to that time the so-called "hand engines" were used exclusively, and it should also be understood that at that time the present-day system of water works was still in its infancy and therefore the chief dependence for a supply of water was upon methods of storage in vogue before water mains came into general use.

The conventional hand fire engine of that day comprised a rectangular wooden box suitably mounted on four low wheels. Pumps of the piston type were housed within, and since at this early period fire hose was not plentiful (the best was crudely made up of leather), the pumps were therefore placed close to the scene of the fire. Water, largely conveyed by a hand-to-hand passing of fire pails, was poured into the engine trough, where it was picked up by the pumps and forced through the leading hose and onward to be thrown on the fire. Somewhat later it became customary to equip these hand engines with a non-collapsible suction hose, so that water could be drawn directly from cisterns or wells, but the wooden tub or reservoir always remained a characteristic feature of these old-time machines.

EARLY STEAM FIRE ENGINES

Early in January 1853, Mr. A. B. Latta successfully tested his new steam-driven fire engine. Mr. Latta was a citizen of Cincinnati, and, although his pioneer effort resulted in the production of an extremely heavy machine, the engine was purchased by the city and known as the *Joe Ross*. This first steamer marked the beginning of a new epoch in fire fighting.

The real basic element of Latta's invention was embraced chiefly in a quick-steaming water-tube boiler, dependent entirely upon a forced circulation of water through the steam-generating coils. The fire pumps were of an ordinary piston type. They were laid horizontally and occupied positions forward on opposite sides of the machine. Two steam cylinders, in alignment with the pumps, were placed so that the pump rods extended to the steam pistons;

[1] President Ahrens-Fox Fire Engine Co. Mem.Am.Soc.M.E.

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while the steam piston rods, passing through the rear cylinder heads, were each coupled to a crosshead and by the use of connecting rods motion was communicated to the two rear wheels of the engine. This arrangement obviously provided means for propelling the apparatus under its own power. As a matter of fact, however, the *Joe Ross* and later engines of similar model were always drawn by horses, as the rear driving wheels could be disconnected from the engine and the pumping mechanism by means of clutches.

Mr. Miles Greenwood, another of Cincinnati's public-spirited citizens and prominent as a manufacturer, was at that time greatly interested in fire-department affairs. He was a staunch advocate of anything which would improve conditions, and to further his unselfish aims he took personal charge and became chief of the department, with the result that, within three months following the installation of the *Joe Ross* engine, the fire-fighting forces were completely reorganized under his leadership and the first paid fire department was inaugurated in the city of Cincinnati. The year 1853, therefore, also marks the beginning of the present paid system, and which has since been extended and generally applied to all large fire departments.

Latta's second steam fire engine was built and installed in the year 1853. The purchase of this machine was made possible by popular subscription, and the engine was named and long known in Cincinnati as the *Citizens' Gift*. From the beginning, Latta's new industry did not result in a monopoly, for rival steam fire-engine builders were soon in the field. Before tracing the further development which followed, it seems proper to refer briefly to the salient factors associated with fire streams and the fire engine.

Essentials of Effective Fire Fighting

It may first be stated that many of the methods employed by fire departments are not properly appreciated, either by the layman or the engineer. The importance of the fire engine is frequently underestimated and the possibilities of averting disaster are also undervalued, this being due in no small part to the fact that the principles involved are not sufficiently understood. There is therefore need for greater knowledge of fire prevention and fire fighting.

When fire must be fought, fire streams can be effective only when the water is expelled from the nozzle at an appropriate speed. In other words, unless enough of the initial pressure available for starting the flow through the hose survives at a point immediately back of the nozzle orifice, the resulting jet will not measure up to its mission. The characteristics of a fire stream—good, bad or indifferent—are directly dependent upon the velocity of the jet, and obviously the velocity is proportionate to the surviving pressure just mentioned. For the best results the flow may be too slow, while on the other hand disappointment will follow when the velocity of discharge goes beyond what might be termed the maximum economical limits of nozzle pressure.

It can be shown that little is to be gained by forcing nozzle discharges at much beyond 100 lb. pressure, and the proper remedy when only such high pressures are available is to substitute a nozzle of larger bore. On the other hand, if the jet seems to lag, it is an indication that the surviving pressure is not high enough to afford the required velocity of discharge, and under these circumstances if the initial hydrant or pump pressure is already at its highest possible point, or if it is also impossible to augment the volume of water passing, then the proper remedy is to substitute a nozzle having a smaller bore.

It may be of interest in this connection to note that the range of nozzle discharge pressures is not large between a stream of inferior reach and the swiftest jet within the economical power limit. While it is true that larger nozzles will "carry" farther at the same velocity than nozzles of smaller bore, yet for practical purposes it will be found that the most efficient fire streams are developed under the following conditions:

A jet issuing at a velocity under 60 ft. per sec. (about 25 lb. pressure) would not be considered a good stream. Above 60 ft. per sec. the jet stiffens, and as the velocity of flow increases the stream becomes the more effective. However, when the flow attains a speed of approximately 120 ft. per sec., with a corresponding discharge pressure of nearly 100 lb. per sq. in., a point is reached where additional forcing fails to contribute much in the way of added distance.

Fire-Engine Performance

The function of a fire engine is either to draw water from any basin or other conveniently located source, or, when fire hydrants are available to make up the pressure which is seldom high enough in ordinary water mains to serve for effective fire service. In fighting fire, it is not uncommon to elevate the nozzle far above the source of the water supply. This procedure, of course, involves loss of forcing pressure, which is in proportion to the static head of the column. The greatest power-absorbing medium between the source of supply and the point of discharge is the fire hose. It may also be said that here is involved the point which is least understood in the subject of hydraulics as applied to fire-fighting practice.

Fire-engine pump pressures must necessarily be kept within limits compatible with the strength of the fire hose, and when working pressures are maintained at upward of 250 lb. there is always considerable risk, because the average fire department is not always supplied with hose which will safely withstand the high pressures which modern fire engines are capable of developing. The initial pressure as indicated at the pumps drops off steadily toward the point of discharge, and it should be well understood that all pressure which is not thus absorbed by the friction of the flow through the hose is finally manifested as velocity at the nozzle orifice. Hence, unless the several factors that enter are considered together it cannot possibly follow that the best results will be attained.

The preceding paragraph expresses the gist of fire-engine performance, and the variable features always associated with the work may be definitely stated as follows:

Pumping Capacity: The number of U. S. gallons discharged per minute—

- *a* At 120 lb.
- *b* At 200 lb. } pressure registered at pump.
- *c* At 250 lb.

Water Supply: The source and adequacy of the supply—

- *d* If at draft—height of lift represented by the vertical distance of water surface below center of pump intake
- *e* If at hydrant—capacity as indicated by pressure registered when water is flowing.

[NOTE: High static pressure, as indicated when hydrant is not flowing, is no index to its capacity to discharge any required volume.]

The Layout: Conditions affecting the discharge are—

- *f* Size and character of the fire hose
- *g* Number of hose lines in use
- *h* Lengths of hose stretched between engine and nozzle
- *i* Number of streams played
- *j* Bore and style of nozzles used
- *k* Elevation at the point of discharge.

During a long period manufacturers of fire engines were unrestricted as to the ratings which they assigned to their machines, and when "gallons per minute" were given, no definite discharge pressures were associated with the expressed pumping capacity. In pumping tests, the actual discharge was seldom checked or verified, with the result that comparisons of fire-engine performance were more a matter of guess than of accurate determination. This condition, however, no longer obtains, and the change is largely due to the exacting supervision initiated and persistently pursued under the auspices of the National Board of Fire Underwriters. A corps of expert engineers is constantly in the field for the purpose of investigating and keeping in touch with the fire-fighting situation in all cities, and pursuant to this policy of the insurance interests, it is now generally known what may be expected of fire engines when new and in prime condition, and periodical inspections disclose weaknesses subsequently developed in service.

According to the standards formulated by the National Board of Fire Underwriters in addition to the normal rating of a fire engine, expressed in gallons per minute, there must also be suffi-

cient power to expel the rated volume of discharge at a pressure of not less than 120 lb. per sq. in. Inasmuch, however, as certain situations may demand higher initial pressures, the pumps must also be so related to the attending power plant that higher pressures can be realized. Therefore further qualifications are demanded, as follows: One-half the rated capacity should be discharged by the pumps at 200 lb. pressure and one-third the capacity at 250 lb. pressure. Furthermore, fire engines should not be limited to 250 lb. pressure, for the fire departments of our large cities are confronted with the so-called "sky-scrapers," and when water must be forced to their upper floors, the overcoming of the static head alone greatly lowers the effective pressure.

However, when the power of an engine is fully utilized in forcing water to extinguish fire in a lofty building the work and the consequent strains are perfectly legitimate. On the other hand, when pressures much in excess of 250 lb. are employed simply to overcome resistance, which could be reduced by a more intelligent use of hose and nozzles, then the work evidently represents not only a waste of power, but also very bad practice.

Losses in Fire Hose

A good engineering axiom to observe is that all work should be accompanied with the least expenditure of force, and the aim here is to express the fact that many firemen have yet to learn how to smooth their own way. The point can best be illustrated by an example.

The inside diameter of fire hose ordinarily used is $2\frac{1}{2}$ in. Cotton-jacketed, rubber-lined hose is the most common kind and lengths of 50 ft. (each such length constituting a section) are the recognized standard. The conventional way of expressing friction loss, or the loss pressure when water is flowing through the hose, is in terms of pounds per square inch for a unit length of 100 ft. for any given rate of flow stated in gallons per minute. This drop in pressure or so-called friction loss varies somewhat with quality or make-up of the hose; varying diameters and the fact that some makes of hose present a smoother waterway than others are also causes which prevent formulating a coefficient which can be applied to all kinds of $2\frac{1}{2}$-in. fire hose and by which friction losses can be predetermined with precision.

It therefore follows from the foregoing statements that all tables setting forth friction loss in fire hose should be accepted only as close approximations, and in actual practice the results may therefore not agree. However, within the range of velocities and the lengths of hose ordinarily encountered in actual service, it has been found that for water flowing through 100 ft. of average good quality $2\frac{1}{2}$-in. rubber-lined and cotton-jacketed fire hose, the friction loss will be about 14 lb. when the rate of the flow represents 250 gal. per min. Accepting this approximation as a basis, it must also be kept in mind that the friction loss increases in direct proportion to the length of the hose; hence, for the same rate of flow (250 gal. per min.) through 200 ft. the total loss would be twice as much as indicated for 100 ft.

The effect of varying the rate of flow follows a different and more intricate law, the friction loss increasing more nearly in proportion to the square of the flow. Therefore, if the loss per 100 ft. is 14 lb. when 250 gal. are flowing, it will be quite correct to assume that it will require nearly 2×2, or four times as much pressure, i. e., 56 lb. to discharge 500 gal. through 100 ft., 112 lb. through 200 ft., etc. Stated as a formula,

$$L = 0.00023G^2$$

where L is the friction loss per 100 ft. of $2\frac{1}{2}$-in. rubber-lined, cotton-jacketed fire hose of good quality, and G is the flow in gallons per minute. The results obtained by using this approximate formula agree closely with those in the tables compiled by Mr. John R. Freeman, which appear in Fire Stream Tables, issued by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

The red book, Fire Engine Tests and Fire Stream Tables, published by the National Board of Fire Underwriters, New York, gives the formula,

$$L = 2Q^2 + Q$$

in which L represents the friction loss, as before, and Q the volume flowing in gal. per min. divided by 100. Mathematical precision is always laudable, but in action firemen could hardly be expected to work out problems other than such as might readily be solved mentally. However, while extreme accuracy is entirely unnecessary in fire fighting, it would seem altogether feasible that fire engines could be set to work with hose layouts arranged with nozzles compatible with the general conditions of a situation, so that the efficiency latent in modern apparatus and appliances would be more frequently realized.

A close approximation, reasonably well gaged according to a correct and definite line of reasoning, is preferable to merely a guess or no system at all. Given sufficient study, the difficulties of apparently intricate hydraulic formulæ will vanish most surprisingly, and the real need today is for a greater cultivation of mental capacity to the end that commanding officers in the fire service become especially proficient in obtaining the best possible results with the apparatus at their disposal.

Nozzle Areas

It will be evident from what has been presented that the characteristic of a fire stream develops according to the following interlocking factors:

a The pressure which survives at the nozzle
b The volume of water reaching the nozzle
c The relation of the nozzle bore to *a* and *b*.

The difficulties which attend in the existing system of nozzle bores are largely due to the fact that the diameters vary after the order of ordinary machine-shop reamers, i.e., $\frac{7}{8}$ in., 1 in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., and it therefore follows that the areas of the orifice have increments which increase in arithmetical progression.

A more logical system has long been proposed, wherein the nozzle orifices would be multiples of a fixed standard. In accordance with this method it was suggested that the $1\frac{1}{4}$-in. nozzle, a size now most common, be designated as "100 caliber." Other nozzles in the same system would be made with orifices of such areas that the water-discharging capacity at the same pressures would be respectively as the caliber number by which each is to be distinguished. Therefore, instead of nozzles measuring $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{8}$, $1\frac{1}{4}$, $1\frac{3}{8}$, $1\frac{1}{2}$, $1\frac{5}{8}$, $1\frac{7}{8}$, $1\frac{7}{8}$ and 2 in. in diameter, the caliber system would leave the $\frac{5}{8}$- and $1\frac{1}{4}$-in. sizes as before, calling these 25 and 100 calibers, with others, to cover practically the same limits, but with fractional bores arranged in multiple, such as 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275 calibers. Table 1 gives these proposed caliber values in more detail, and for a complete discussion the reader should consult Caliber of Fire Streams, Report of Transactions of the International Association of Fire Engineers, 1911.

TABLE 1 CALIBER SYSTEM OF STANDARD FIRE STREAMS

Devised and Proposed by Charles H. Fox

Caliber Value	Area, Sq. In.	Diam. of Bore, In.	Nominal Diam., In.
25	0.3068	0.625	$\frac{5}{8}$ Exact
50	0.6136	0.883	$\frac{7}{8}$ plus 0.008
75	0.9204	1.082	$1\frac{1}{8}$ plus 0.019
100	1.2272	1.250	$1\frac{1}{4}$ Exact
125	1.5340	1.397	$1\frac{3}{8}$ plus 0.022
150	1.8408	1.530	$1\frac{1}{2}$ plus 0.030
175	2.1476	1.652	$1\frac{5}{8}$ plus 0.027
200	2.4544	1.767	$1\frac{3}{4}$ plus 0.017
225	2.7612	1.875	$1\frac{7}{8}$ Exact
250	3.0680	1.976	1 $\frac{15}{16}$ plus 0.039
275	3.3748	2.072	$2\frac{1}{16}$ plus 0.010
300	3.6816	2.165	$2\frac{1}{8}$ plus 0.040
325	3.9883	2.252	$2\frac{1}{4}$ plus 0.002
350	4.2951	2.337	$2\frac{5}{16}$ plus 0.025
375	4.6019	2.420	$2\frac{3}{8}$ plus 0.045
400	4.9087	2.500	$2\frac{1}{2}$ Exact

NOTE:—The true basic caliber unit is the area of a circle $\frac{1}{8}$-in. in diameter, viz., .012271875.

THE RETURN OF THE ELEVENTH ENGINEERS

AFTER 22 months of service over seas the famous Eleventh Regiment of Engineers, which made a glorious record at Cambrai, returned to America, and on April 30 marched down Fifth Avenue in final review, 1300 men strong. Col. Wm. Barclay Parsons and his staff, accompanied by Lt. Col. William T. Chevalier, headed the parade and the regiment was reviewed by Governor Smith, Mayor Hylan and other prominent men. Following the parade a dinner was tendered by the Military Engineering Committee and thus was brought to a fitting close the career of the Eleventh Engineers in the Great War.

This is the regiment which was recruited by the Military Engineering Committee of the Engineers' Club of New York, with which in this effort the National Societies of Civil, Mechanical, Mining and Electrical Engineers coöperated. Recruiting began before war was declared, for the purpose of forming a reserve regiment of engineers, and the Eleventh Engineers proved to be the first step toward the organization of the National Army.

The deeds of the Eleventh Engineers have been followed with the greatest interest by engineers throughout the country and the following abstract of a recent article in the New York *Evening Post* by Col. Wm. Barclay Parsons gives a brief history of "the Fighting Engineers."

Sailing on the *Carpathia* from "an Atlantic port" in the middle of July, the regiment arrived at Plymouth and was promptly ordered to a camp at Borden, in the Aldershot district. On July 18, it was reviewed by King George, having the honor of being the first American unit to be reviewed by a King of England.

Our training at Borden began in the use of gas masks, but before the instruction was completed we were ordered to the continent, arriving at Boulogne the evening of August 7. From there we were ordered to Audruicq and finished our instruction in the gas school at Calais. We were then ordered south to Plateau, in the valley of the Somme, northeast of Peronne and to our regiment was assigned the task of getting the railroads there in improved physical condition, building sidetracks, which were intended later to receive fleets of tanks, and also to prepare for the reconstruction and maintenance of the Nord railroad from Peronne to Cambrai. All the territory had been in German hands but had been abandoned in the retirement of February and March, 1917, following the battle of the Somme, in the summer and fall of 1916.

When the Germans retired they had destroyed this road, blowing up bridges and removing the rails and ties. Part of the line to be reconstructed was in advance of the British guns; part of it was in view of the German first line trenches. It was imperative, however, that our labor attract no attention from the enemy. The work was done in scattered pieces—first in one spot and then another—and sometimes we worked at night.

While engaged in this work two of our men were wounded—Sergeant M. J. Calderwood and Private Brannigan. These men were the first American sodiers to be wounded in an engagement in France.

On our arrival at Peronne we were assigned to the British Third Army under General Byng. By the end of October we knew an attack was planned on Cambrai. This attack was not to be preceded by heavy artillery fire, according to past custom, but instead, there was to be a surprise advance by the fleets of tanks, which had been unloaded on the sidings the boys of the Eleventh had constructed.

Two weeks before the battle all conditions favored the British. The country was completely shut in every night by a dense fog, making it impossible for the enemy to detect our movements. All through the night the British moved forward with troops, guns, ammunition, and tanks. All was quiet in the daytime and the German aviators could find nothing.

The battle began on November 20. Six-thirty was the zero hour. The attack was successful beyond expectations. The Germans were completely surprised. By two o'clock on the same afternoon I personally was a mile and a half beyond the Hindenburg line. That night the attack had progressed sufficiently for our men to begin laying track on the roadbed they had already constructed. The Germans had abandoned their railhead and when the Americans laid rails up to the beginning of the German road there was connection between Paris and Berlin for the first time since 1914.

The British advance continued until November 22, when a heavy artillery duel took the place of infantry action. The British had gained 6 miles, had captured 11,000 prisoners, and had inflicted heavy casualties with slight losses to their own forces.

On the morning of the 30th the Germans began their celebrated counterattack. It was concentrated at two points, Moevres on the north and Gouzeaucourt on the south. The northern attack failed, but at Gouzeaucourt the British line was lightly held, and the Germans, acting as the British had previously without preliminary artillery warning, broke through in great masses.

Our men, suddenly surprised at their work, were without arms. The gray-clad German forces were seen rushing up the road. Hurriedly a miscellaneous force was gathered to stem the advance. Seizing picks, shovels, the few rifles they could find—anything—the Americans joined what British infantry was available. The defence soon took the form of hand-to-hand fighting, the Americans and British battling desperately to halt the Germans, greatly superior in numbers. While our resistance was not sufficiently powerful to stop the Germans, it did delay them and enabled the British to reconstitute the holding line.

We suffered heavily in killed, wounded and prisoners. It was the first real fight of the war in which American forces had taken part. The fighting continued severely all day. At night the British held and the Americans took positions in the back-line trenches in case the Germans renewed their offensive. Finally the British straightened their lines by giving up part of the territory they had gained and leaving our rail connection in German hands.

At the end of January, 1918, we were withdrawn and ordered to report for duty in central France in the construction of railway lines and yards. On March 21 the big German offensive began. The Allies realized it was a really dangerous attack, aiming to break through to the Channel ports and sever the British and French armies. The British asked General Pershing for two regiments of engineers. The 11th was the first to be selected.

On our arrival in the northern sector we were assigned to the First British Army under General Horne. Our first duty was to build trenches and other defence works just behind Arras, the British having laid out a very complete series of trenches, one behind the other, realizing that a further German advance would seriously cripple the lines of communication. The British program was to hold at whatever cost.

After a month we were moved further north, just south of Bethune, to engage in the same kind of work. During the two months we were there we built about 36 miles of complete trenches, 6 ft. deep, with fire-steps, machine gun posts, dugouts, tunnels, drains, and all other details of trench construction. We also put in place about 7 miles of heavy wire entanglements.

We were kept in this section until the middle of June, but the Germans failed to renew their offensive. Then we were moved south again. One battalion was posted below Chateau-Thierry to build an ammunition dump. The other half of the regiment was sent east of Issoudon for the same purpose.

At the end of August we were ordered to report to the chief engineer of the First Army to make reconnaissance for changing a meter gage railroad into a standard-gage line and for strengthening the bridges so they could bear heavier traffic. This line was just south of St. Mihiel, running from Commercy through the French lines, across No Man's Land to the German lines east of St. Mihiel, and north to near Verdun. So the regiment proceeded to Commercy. As in the Somme country in the previous year, we began working in small groups so as to attract the least attention. The line was rebuilt, following up the American advance with both ammunition and food.

On September 24 orders were received for half of the regiment, with headquarters, to go north and build a new railroad line down the valley of the Aire, through points which were then well behind the old German lines, the work to begin immediately following the opening of the attack. This attack is known as the Battle of the Argonne. Later, as the movement developed, more of the regiment was ordered to participate, being located north of Verdun. In this district we remained, improving communications which would facilitate further Allied advances, until the armistice was signed.

Before the Eleventh Engineers left France the general staff authorized the placing of five silver bands on the staff of the regimental colors, denoting as many major engagements, as follows: Cambrai offensive, Nov. 20-24, 1917; Cambrai defensive, Nov. 30-Dec. 3, 1917; St. Mihiel offensive, Sept. 12-16, 1918; Toul sector, Sept. 25-Nov. 11, 1918; Meuse-Argonne offensive, Sept. 26-Nov. 11, 1918.

Value of Government-Owned Machine Tools

Referring to the note in the April issue of MECHANICAL ENGINEERING regarding Proposals for Technical Institutions to Obtain Government-Owned Machinery, in which through a typographical error it was stated that there are probably $2,000,000 worth of these machines throughout the country, a member writes as follows:

At the Rifle Plant of the Midvale Steel and Ordnance Company, Eddystone, Pa., there were 11,000 machine tools which were government-owned, and placing the extremely low valuation of $500 per machine it will be readily seen that there was more than $5,000,000 worth of machine tools at this plant alone.

The American Brake Shoe and Foundry Company was given more than $8,000,000 for its plant at Erie, Pa. Altogether there were approximately 300 plants which were Government-aided with "increased facilities" and it is doubtful if any of these plants received less than from two to three hundred thousand and many of them went into a million or several millions of dollars. This estimate applies only to army ordnance.

A rough estimate of the amount expended for machine tools to provide increased facilities for Government contractors is about $250,000,000.

Mechanical Lifts—Past and Present

And Particulars Regarding a New Balancing Method in Which the Movements of the Supporting Elements Are Synchronized

By LIEUT. J. F. ROBBINS,[1] U. S. N. R., WASHINGTON, D. C.

In this paper the author first describes at some length the various types of mechanical and hydraulic lifts that have been developed for use in canal locks. He then gives particulars regarding a new type of lift in which the points of support of two counterbalancing loads are so interconnected that the movements of the supporting elements of the structure are synchronized and it is made impossible for the supports to get out of level. The advantages of this scheme and its adaptation to freight-car lifts, lifts for launching and dry-docking, and lift bridges, as well as to canal-lock lifts, are also brought out.

MANY types of mechanical lifts or elevators for lifting vessels over elevations have been proposed and built in the course of the development of waterways. However, the original principle involved in the masonry lock invented by Leonardo da Vinci still holds its superiority mainly because efforts to develop mechanical lifts have failed to keep pace with the increasing size of vessels to be transported.

The inclined railway for hauling the load up and over elevations by cable served its purpose, to a certain extent, in the early days of canal development, but had its apparent limitations.

A gated tank on wheels was built in 1874 on the Chesapeake and Ohio Canal, to be hauled up an incline by means of cables with counterweights, but failed in its practical application.

FIG. 1 PETERBOROUGH HYDRAULIC-LIFT LOCK, TRENT CANAL

In the same year, 1874, Edwin Clark, an English engineer, invented and built the first balanced hydraulic lift lock. This structure, built at Anderton, England, provided means for transferring vessels between levels of the canal on single plunger lifts.

Clark and his associates later built balanced lifts at La Louvière, Belgium, and Les Fontinettes, France, having a lift of 50 ft., the lock chambers being 140 ft. long and 19 ft. wide with a navigable depth of 7 ft. 10 in. He also proposed to use this principle for transferring trains of freight cars between different levels, but did not put the idea into practical use.

CANAL LIFT DEVELOPED IN GERMANY

In Germany much work has been done in developing mechanical lift locks. Hoffman, a German engineer, invented and built a floating lock supported on tanks; and later, in the Dortmund and Ems Canal, locks were built on this principle, having a lift 68.5 ft. The lock chamber was built in the shape of a box with end gates 229.6 ft. long, 28.2 ft. wide and 8.2 ft. deep, supported on five steel cylinders or tanks. The weight of the structure and water load was supported by the buoyancy of these tanks, which floated in wells 30.17 ft. in diameter. The lift is made in approximately 15 min. by four large screws operated by 150-hp. motors. This installation, while larger than any mechanical lift previously built, fails to take advantage of the counterbalancing effect that obtains in the balanced lifts built by Clark. This necessitates a considerable expenditure of energy in overcoming the attraction of gravity which is, of course, unnecessary in any form of balanced lift.

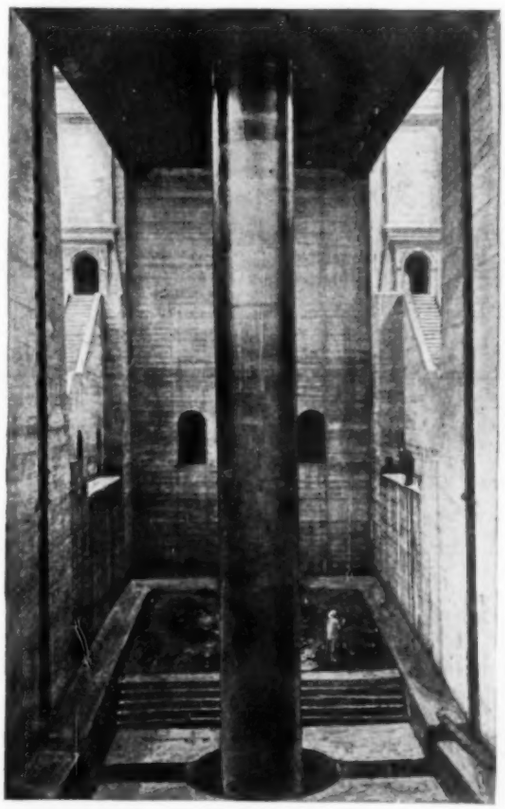

FIG. 2 ONE OF THE PLUNGERS OF THE PETERBOROUGH LOCK

The firm of Hoppe in Berlin has made a study of the application of a multiple of hydraulic plungers for operating large lifts, but found an insurmountable difficulty in maintaining the perfectly uniform and synchronous movement of a number of plungers which is absolutely necessary when handling loads greater than can be carried on one plunger.

TRENT CANAL LIFT LOCKS

The largest and most successful example of the application of the balanced hydraulic lift was built in 1905 in Canada in

[1] Bureau of Steam Engineering, Navy Dept. Assoc.-Mem.Am.Soc.M.E.

For presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

the Trent Canal at Peterborough.[1] This lock, shown in Fig. 1, together with the similar one at Kirkfield on the Trent Canal, has been in successful operation since put into commission and has various economic advantages over the masonry type of lock. The total lift of 65 ft.—over twice the height of the lift of the Panama Canal locks—has been made in the record time of 6½ min., the average time necessary to pass a vessel being from 10 to 12 min. Since only a comparatively small amount of water is used in making a lockage, most of the normal flow through the canal is available for water power, some of which is used for operating auxiliary pumps and lighting.

The lock at Peterborough consists of two steel boxes 140 ft. long, 33 ft. wide and carrying 10 ft. of water, each supported on its centrally located plunger 7½ ft. in diameter with a 65-ft. stroke. (Fig. 2). The cylinders or presses into which the plungers extend are connected by a 12-in. pipe with a gate valve, so that with one box with its water load at the upper level and the other at the lower level of the canal, by opening the valve in the cross-connection the position of the lock chambers is changed and the lockage made.

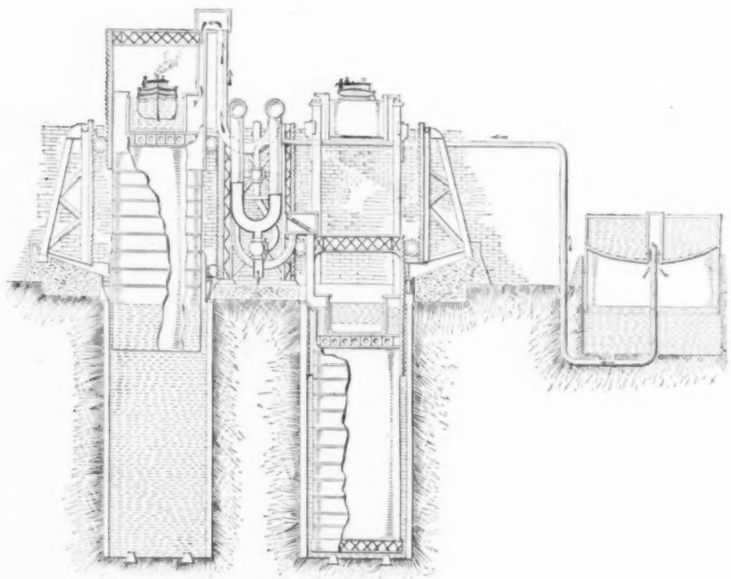

FIG. 3 AIR-SUPPORTED LIFT LOCK PROPOSED FOR N. Y. STATE BARGE CANAL

The stroke of the plungers has been set so that the box at the upper level stops with the water level in the box about four inches below the water level in the canal, and takes on this additional water load. This excess load, amounting to about 50 tons, when taken into the upper lock acts as a surcharge to overcome friction and gravity and bring the upper lock down and the lower one up.

When it is desired to transfer a boat from one level to the other, the boxes being in their respective positions at the end of the stroke of the plunger, the clearance between the end of each box and canal is first closed by inflating an air hose laid down the side walls and across the sill. Then this clearance space is filled through wicket gates in the end gates of the lock and canal. The clearance space having been filled and water levels in canal and lock having been equalized, the end gates which are hinged across the sill of lock and canal are folded down, making a continuous stretch of water from the canal to lock. Then the vessel is moved into the lock, displacing its own weight of water, of course, so that the load is constant, regardless of the size of the vessel. After the entrance of a vessel into one or both of the locks the end gates are closed, the clearance space emptied, and the cross-connection valve gradually opened, allowing the upper box to come down and forcing the lower one up.

While this installation of balanced lifts has proved to be economical in first cost, operation, time and quantity of water required to make a lockage, the locks are not large enough to accommodate vessels or cargo barges of very great capacity.

It was found, however, that the size and load to be handled were about as extensive as could be supported on the cantilever structure of the box over one plunger. Also, the total weight of one lock chamber, plunger and water load, which is in the neighborhood of 1900 tons, was about the maximum that could be safely supported on the masonry foundation for the cylinder castings.

For these reasons, and because no scheme has been found for safely supporting the load on more than one plunger, no balanced lift has ever been built of greater size than the one at Peterborough.

PROPOSED LIFT LOCKS FOR N. Y. STATE BARGE CANAL

A vertical lift lock was proposed for the Erie Canal at Lockport, N. Y., where a single mechanical lift was to take the place of a double flight of masonry locks there used to overcome an abrupt change in elevation of 56 ft. The design called for a steel box 225 ft. long, 29 ft. wide, and 9 ft. deep, which was to be supported by 88 link-and-pin chain cables attached to floor beams and running up and over sheave pulleys and down to 1000 tons of cast-iron counterweights. The sheave pulleys were to be carried by steel shafts supported, one on each side, in the permanent structure built at each side of the canal. The movement of the load was to be controlled by a number of brakes on the shafts.

At Cohoes, on the New York State Barge Canal, the installation of a mechanical lift lock was seriously considered, and a board of engineers investigated and reported on three different designs. Here, in the place of 16 masonry locks, it was proposed to install a pair of balanced lifts to overcome an elevation of about 120 ft. The specifications called for two counterbalancing tanks 310 ft. long, 28 ft. wide, and 12 ft. deep, each capable of floating two vessels of 1000 tons capacity. The three designs considered proposed to make use of three different supporting mediums; air, sets of cables, and hydraulically operated plungers.

Air-Supported Lifts. In the pneumatic design the weight of the steel box, or lock and water load, was to be directly supported on the elastic cushion of air maintained under the load by having the steel sides of the box extend downward below the surface of water maintained inside a large rectangular caisson built in the canal. See Fig. 3.

The two similar structures, either in tandem or parallel, were to have the air space under each box connected by huge air mains 21 ft. in diameter, with the necessary return bends and valves for shifting the supporting air from the space below one lock to the other when the locks were to be shifted between levels.

Cable-Supported Lifts. The second design considered by the board of engineers covered a pair of steel boxes of the specified dimensions supported by numerous cables running over sheave pulleys on the permanent structure from one box to the other, each load thus counterweighting the other and being shifted from one elevation to another by a surcharge of water in the upper box.

Plunger-Supported Lifts. The third proposal covered a pair of steel boxes working up and down in balance with each other and supported on three steel plungers under each load. The cylinders were to be connected by piping with suitable valves so that when the upper lock came down the lower lock would be forced up, registering with the upper level of the canal. As in the pneumatic scheme, it was recognized that some device for maintaining the level of the box would be necessary. In

[1] This lift has been fully described and illustrated in the *Scientific American*, July 7, 1906, the *Engineering Record*, March 30, 1907, and various other engineering publications.

this case the movement of the three plungers was to be coordinated by a central counterweight directly connected with both ends of the tank "in such a manner that the weight would always act to overcome the effect of any unbalanced load."

In this, as well as in the second proposal, the equilibrium of the structure and water load was to depend on the operation of a mechanical device, the positive action of which would be questionable for maintaining the level of an unstable water load.

The report of the board of engineers shows considerable interest in the future possibilities of the hydraulic plunger lift, but recommended four masonry locks with a lift of 28 ft. each.

Proposed Cable-Supported Lift Locks

An interesting design for a balanced lift lock has been described by Dr. J. A. L. Waddell[1], in connection with the proposed Lake Erie and Ontario Sanitary Canal and Power project. See Fig. 4.

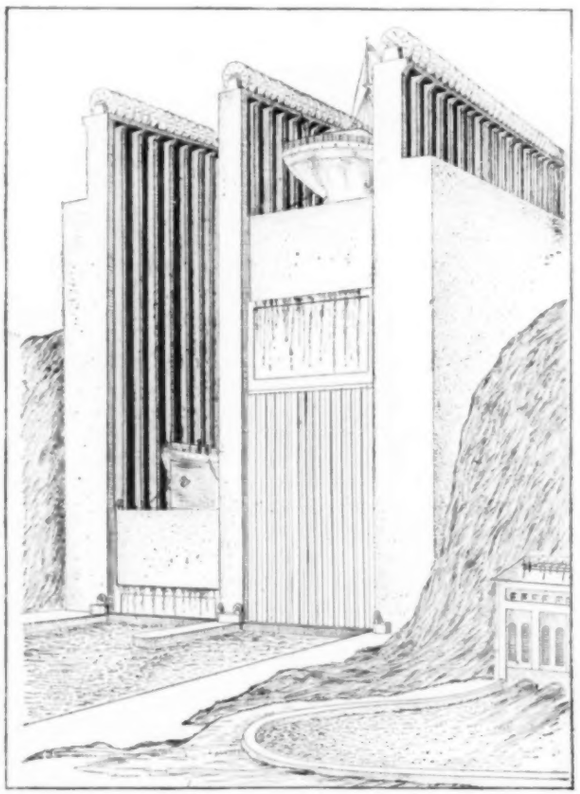

Fig. 4 Cable-Supported Lift Lock Proposed for Lake Erie and Ontario Sanitary Canal

Here, in order to make available for power purposes the water which would be used for lockage in the masonry type of lock, it is proposed to install two pairs of balanced lifts, one of 208 ft. and one of 104 ft. lift. The lifts, as described, are to be supported by cables connecting the inboard side of the two parallel boxes and running over fifty-six 20-ft. diameter sheave pulleys, mounted on the retaining wall between the boxes. The outboard edge of each box is connected by a similar set of cables running over pulleys and to counterweights suspended outside the two outer retaining walls.

This design, adopted as the most feasible *known* method of overcoming the high lift with locks of large size, is somewhat similar to that which was proposed for the New York State Barge Canal. It is believed that there would be considerable difficulty in maintaining the equilibrium of these lock chambers, which are to be 660 ft. long, 70 ft. wide, and carrying 30 ft. of water; and that some extensive braking apparatus would be necessary on the sheaves or supporting shafts. Any excess load on one end of one lock, tending to force it down, would lift the same end of the other up and would be cumulative in effect with the water load.

[1] *Scientific American*, March 23, 1918.

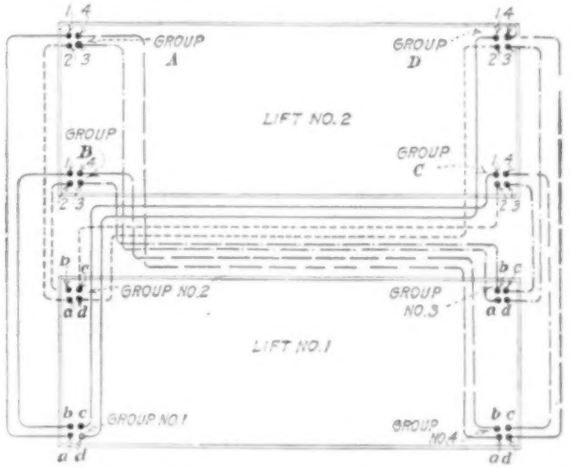

Fig. 5 Diagram Showing Connections for Harris Balanced Lifts

Lift No. 1: Plungers of Groups Nos. (1, 2, 3, 4) connected to plungers Nos. (1, 2, 3, 4) of Groups (A, B, C, D) of Lift No. 2, and conversely from Lift No. 2 each plunger of Groups A, B, C, D is connected to a similar plunger in Groups (1, 2, 3, 4) of Lift No. 1.

(Plungers of each group of one lift are hydraulically connected to the four corners of the other lift, so that the pressure due to one lift is uniformly distributed to the other, making it impossible for either lift to get out of level)

As has been well said by the inventor of one of the many designs of balanced lifts. "No mechanic has yet put into successful operation an apparatus in which a number of hydraulic plungers are so controlled and synchronized as to move at equal speed, as they must in operating a lock chamber."

This difficulty of synchronizing the movement of a number of supporting plungers has stood in the way not only of the development of hydraulic lifts of a size sufficient to meet the demands of modern canals, but also has prevented the use of balanced lifts in other applications where their use might be the means of solving urgent economic problems.

A Basic Principle Solving the Balancing Problem.

Through many years of study of this problem no feasible scheme has been proposed up to the discovery of the simple method of interconnecting systems of balancing plungers, or cables, as hereinafter presented.

This scheme virtually does away with limitations as far as size of the lift and load to be handled is concerned. The accompanying diagram, Fig. 5, illustrates this principle of interconnecting the points of support of each load. As indicated in the figure, each lift is supported by a group of four plungers (or cables) at each corner. The plungers *a*, *b*, *c* and *d* in group No. 1 of lift No. 1 are hydraulically connected with plunger No. 1 of groups *A*, *B*, *C*, and *D* of lift No. 2; plungers in group No. 2 of lift No. 1 are connected with plunger No. 2 of groups *A*, *B*, *C* and *D* of lift No. 2; plungers in group No. 3 of lift No. 1 are connected with plunger No. 3 in groups *A*, *B*, *C* and *D* of lift No. 2; plungers of group No. 4 of lift No. 1 are connected with plunger No. 4 of groups *A*, *B*, *C* and *D* of lift No. 2. Conversely, from lift No. 2, each plunger of groups *A*, *B*, *C* and *D*

is connected to a similar plunger in groups Nos. 1, 2, 3 and 4 of lift No. 1.

Thus the plungers of each group of one lift are hydraulically connected with the four corners of the other lift, so that the pressure due to one load is uniformly distributed to the other.

A simple illustration of a cable-supported lift of this type is shown in Fig. 6, in which two shelves are supported by 16 cords. In this model four cords are white, four are red, four are brown and four are blue and white twisted. In the figure the red and brown cords cannot be distinguished from each other.

To each corner of shelf No. 1, supporting the glass of water, four cords of the same color are attached, each cord passing through a screw eye directly above the point at which it is attached. The four white and four twisted cords can be followed in the figure from the corner to which they are attached, up through the screw eyes, across the frame, where one of each color passes through a screw eye over each corner of shelf No.

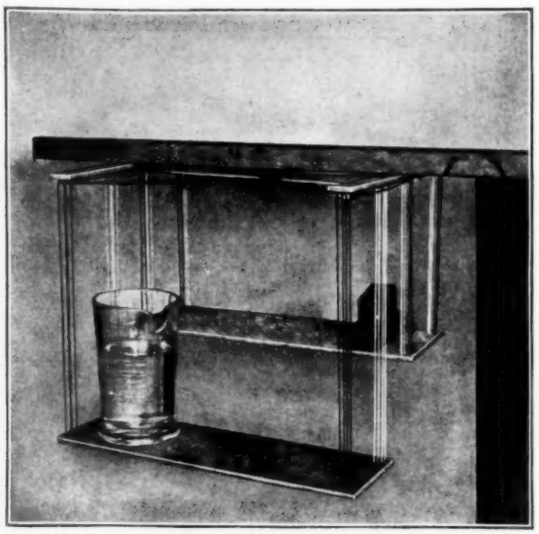

FIG. 6 SIMPLE MODEL OF HARRIS TYPE OF BALANCED CABLE-SUPPORTED LIFT

2 supporting the lead weights and finally down to each corner of shelf No. 2, where they are attached.

If pressure is applied downward on the corner of shelf No. 1 where the white four cords are attached, the other ends of these cords being attached to the four corners of the shelf carrying the weights, the latter shelf will be raised and will at all times be level. Also, since the red, brown and twisted cords are carried in the same way from the other three corners of the first shelf to all corners of shelf No. 2, no part of either shelf can move up or down without all parts of the other shelf moving an equal distance in the opposite direction.

Any part of either shelf will sustain loads equal to the full combined strength of the cords supporting that part.

The device is not limited to any one size or shape in securing these results. If the shelf is too long to carry the necessary load by the cords supporting it at the corners, a second group of cords can be attached to each shelf at any equal distance from the center of each shelf, carrying from each part of shelf No. 1 to each corresponding part of shelf No. 2, and duplicating the arrangement of the first set, these shelves can then be loaded to the combined strength of the 32 cords and at the same time practically divided into three sections as to their strength for carrying these loads. Then, if force enough to overcome the combined friction of all the cords be applied to either shelf, all parts of each one will travel up or down the same distance at the same time.

It is apparent that with the two loads supported in this manner, either by plungers below the lifts, or overhead cables, no load, up to the limit of the design of the structure, could force either lift out of its normal plane or level, however eccentrically the load might be placed. If it were desired to build a pair of lifts several hundred feet long, the total length would be divided into a certain number of spans required by economy of design, and the required number of similar systems of balancing plungers would be used and the various systems connected as shown in the sketch of a single system. Thus, by increasing the number of similar systems it would be possible to build lifts of practically unlimited size.

FREIGHT LIFTS

The utilization of the potential energy of one of two similar loads to shift them between different levels, has only been applied in a large way to the transfer of vessels in canals. But the foregoing illustrated scheme of supporting two such loads makes it feasible to apply the principle to other uses.

Clark's idea of transferring trains between different levels on single-plunger lifts may now be applied to the handling of freight between subway and surface levels, on lifts of sufficient size to carry any number of freight cars.

In view of the difficulty and expense of present methods of delivering freight, for example, into New York City by car ferry and the fact that no feasible method has hitherto been proposed for getting freight from subways to surface levels other than the hauling of trains up inclines or breaking freight below and lifting it on elevators of small capacity, this scheme is put forward as a solution to the problem of overcoming freight congestion.

With the increasing value of real estate, the use of large surface areas becomes prohibitive, making many floors above and below surface levels necessary. This scheme, applying balanced lifts to freight-terminal warehouses and points of distribution, would obviate present long hauls both by truck and train, and make it possible to utilize space to the greatest advantage.

For the handling of freight it would be advisable to design the lifts so that a certain load could be lifted up in excess of that coming down. This could be done by having a certain number of lifting plungers under each lift with a pumping plant of the necessary capacity to lift the excess load.

Fig. 7 shows a typical design of a freight lift for handling fifteen cars on each of two three-track bridge structures between subway and surface levels. After assuring the level and uniform travel of the lifts by a certain number of balancing systems of plungers, certain plungers of the remaining groups have their pipe connections led through a pumping plant for controlling and lifting excess loads.

While it is true that in less-than-carload-lot freight terminals the outgoing tonnage is usually two or three times the incoming tonnage, this capacity for lifting a certain per cent excess load would be advisable and methods of handling such incoming and outgoing freight would have to be so coördinated as to make use of the loads in so far as possible. The available portion of the potential energy of the excess outgoing tonnage might be used to advantage to lift occasional excess incoming loads by storing the excess energy in accumulators and using it to assist in elevating incoming tonnage.

LIFTS FOR LAUNCHING AND DRY-DOCKING

This principle may have a possible application in the field of shipbuilding in connection with the dry-docking and launching of vessels. For example, it might have been applied to advantage in the launching elevator recently built at the Ford plant for launching Eagle boats. In this installation two pairs of simple hydraulic jacks on each side of the platform are used to support the movable structure and boat and to lower the boat into the water. It is then necessary to pump the jack plungers and platform back up into position.

An elevator of this kind might be supported by groups of four plungers under each corner with a nearby counterweight to balance the weight of the platform, supported on an equal

number of plungers. With the plungers connected as described, there would be no possibility of their tipping or binding, of plungers, even though the platform were eccentrically loaded. The counterweight would bring the platform back up into position, without the necessity of a pumping plant or any power for control or operation.

Lift Bridges

This scheme may be applied to lift bridges where the span is too great for the use of the so-called "jack-knife" bridge. Here again the bridge structure could be supported by four plungers at each corner connected to four plungers under each corner of the counterweight situated under the roadway at one end of the bridge. The plungers under the counterweight might be two or three times the diameter of the plungers supporting the bridge, and so reduce the stroke of the counterweight to one-half or one-third of that of the bridge.

The same principle of interconnecting the points of support of bridge and counterweight may be applied with supporting cables instead of plungers. It is probable, however, that the plunger lift would be the most economical design as no heavy overhead truss would be necessary and the towers now used in counterweighted vertical-lift bridges to support the overhead truss, counterweights and motors could be made very much lighter, since these towers would only be needed as guides at each end of the bridge.

The movement of the bridge would be properly regulated by a train of throttling valves in the system of interconnecting pipe lines, and all operations would be governed by an interlocking system of automatic control.

Balanced Lifts as Applied to Erie and Ontario Canal Projects

While the lift of 208 ft. in the proposed lock of the Erie and Ontario Canal project is considerably higher than any existing plunger lift, it is within the range of the feasible application of a multiple of supporting plungers. Such lifts as are proposed, supported on plungers, would be absolutely positive in their relative movement and would have their equilibrium and level assured without auxiliary apparatus. Plunger lifts would render unnecessary the immense counterweights, the total weight of which has to be equivalent to the weight of one lock with its water load. By supporting the loads on plungers below the structure, the retaining walls, which support the sheaves and total weight of the locks, could be made very much lighter as they would be needed simply to act as guides to the movable structure. With these locks supported on the proper number of systems of balancing plungers, as determined by economical design, the groups of four plungers at several points in their travel upward would pick up guides to act as stiffeners similar to those used with long single plungers of passenger elevators. These guides would hang by chain or cable from the lock structure and would be provided with a loose collar for each plunger and guide in tracks in the side walls, thus breaking up the unsupported length of the plunger columns sufficiently to carry the load without bending.

In the cable-supported lifts described by Dr. Waddell it is proposed to use electric motors connected to the sheave pulley shafts for shifting the locks. Since the friction of the extensive cable system and the inertia of two such loads, estimated to be approximately 50,000 tons each, would be very great, this would entail a considerable expenditure of power. In view of this fact it would seem more economical to make use of a surcharge of water in the upper lock for shifting the locks, similar to the manner in which the Peterborough locks are operated. With the two loads supported on systems of balancing plungers, assuring perfect synchronism of movement, control in starting and stopping would be maintained by a train of simultaneously operated throttling valves in the various interconnecting pipe lines.

The proper sequence of events in the operation of such an installation, as a whole, would be governed by semi-automatic interlocking control systems under the supervision of one man, so there would be little possibility of anything going wrong.

Figs. 8 and 9 illustrate the hydraulic-plunger application of this principle. Fig. 8, a view of the underneath side of Model No. 3, shows the four pipes running from the four balancing plungers at each corner of one platform to the four corners of the other platform. Under the middle of each platform are two groups of four pump plungers connected to a common pipe through a small geared pump to the other platform. At the left end of the model is a small accumulator, with a hand pump, which can feed through a common pipe and check valve in each of

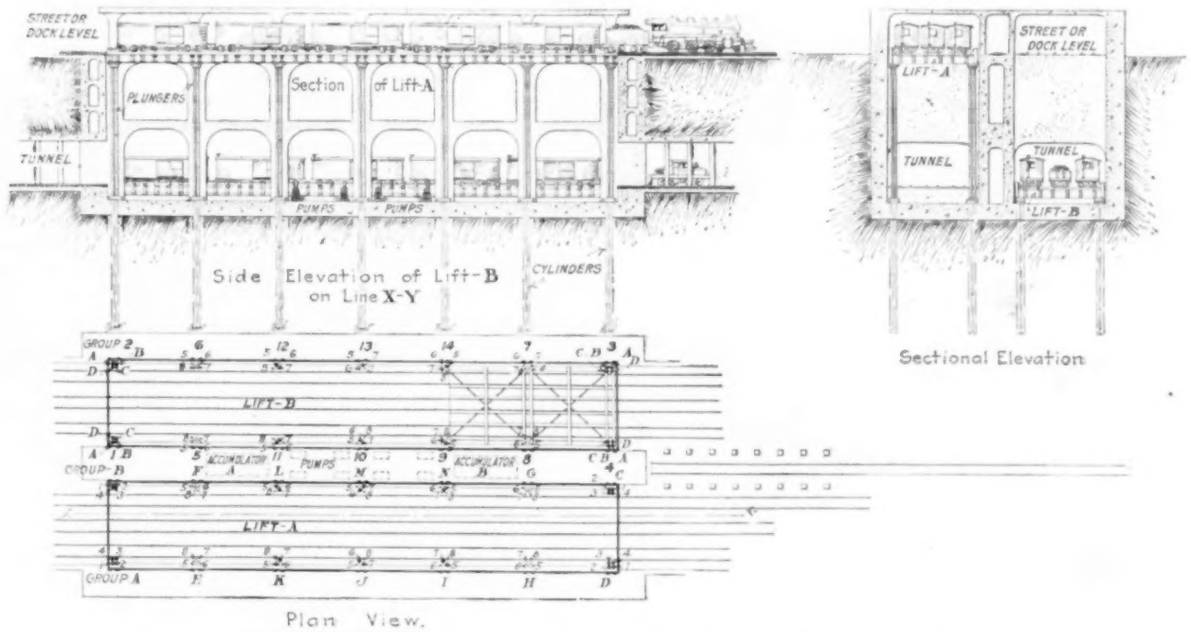

Fig. 7 Typical Design of a Hydraulic Balanced Freight-Car Lift

the 16 small pipe connections between the balancing plungers. The accumulator is kept under sufficient pressure to feed through any check valve to replace leakage in any part of the system. Another train of check and throttling valves, one in each of the 16 interconnecting pipe lines—connects to a common pipe and back to the accumulator for throttling down the platform that happens to be in the upper position when it is desired to put the lift out of commission for repairs.

In the other view of Model No. 3 (Fig. 9) the pump plungers were secured down out of the way, and a load of two pigs

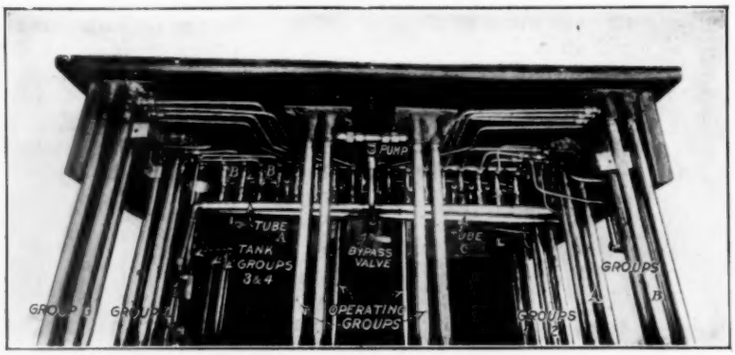

FIG. 8 VIEW UNDERNEATH MODEL NO. 3 OF HARRIS HYDRAULIC BALANCED LIFT, SHOWING PLUNGERS, PIPING CONNECTIONS, ETC.

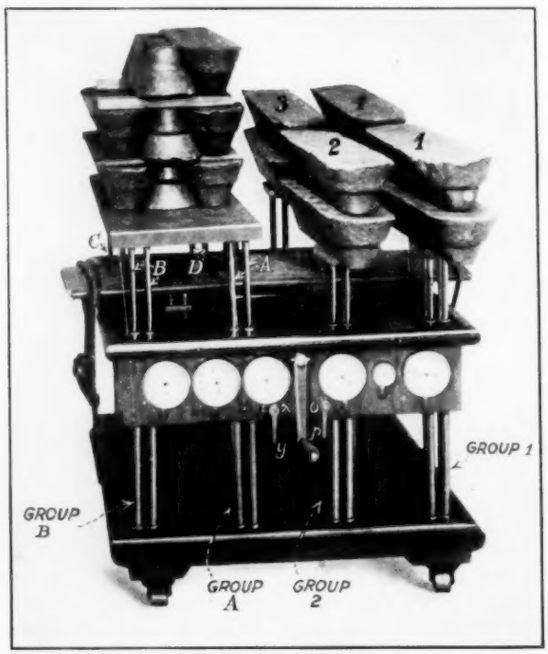

FIG. 9 MODEL NO. 3 WITH EACH GROUP OF PLUNGERS OF ONE LIFT CARRYING INDIVIDUAL LOADS, AN EQUAL LOAD RESTING ON THE PLATFORM OF THE OTHER LIFT

of lead was balanced over the cap of each set of balancing plungers. An equal load was placed on the other platform. With the model loaded in this way, it was possible to force down any one of the four groups of plungers by the pressure of the hand, when the other platform would rise and the remaining three groups of plungers would descend at the same rate; showing that no dependence was necessary on the platform structure for maintaining the level of the groups and that no strains would be produced in such a structure for maintaining the loads level. Moreover, when loads of 1200 lb. were placed eccentrically on each platform, the lifts remained level when moved up or down by means of the pump and pump plungers.

The gages on the front of the model were installed for the purpose of studying the various pressures. The first one on the right shows the accumulator pressure; the small gage indicates the pump pressures, and the remaining four gages are installed in the pipe lines from the cylinders of one group of balancing plungers.

In its application to canal-lock lifts this principle has no limit to which it may not be extended. It may be applied in the great canal systems being developed in Canada, and in the possible future canalization of the United States for ocean-going shipping. It has the very great advantage of economy of water necessary to supply the leakage of vessels. This feature makes it possible to build canals over territory where the rainfall over areas at summit levels is insufficient to supply the water necessary for lockage in the old masonry type of lock. This matter of taking the water supply now used for water power for use in proposed canal systems has alone been a considerable item of cost of proposed waterways.

While this scheme of interconnecting points of support of two loads, as described, has been granted basic patent rights and some little work has been done in the design and development of models and in anticipating the many engineering problems involved, no application of it has yet been undertaken.

It is believed, however, that by the development of this principle of so connecting the points of support of two counterbalancing loads as to synchronize the movement of the supporting elements of the structure and make it impossible for the loads to get out of level, its inventor, William Thomas Harris, of Chicago, has solved an important mechanical problem and has opened a way to the future development of waterways and to more efficient methods of handling freight.

The shipment of 50 locomotives without the use of lighters was recently accomplished directly from Erie Railroad Pier H at Weehawken, N. J., into the holds of the single-decked ocean freighter *Feltore*. The work was done with the standard pier equipment, and no special preparations were necessary. Direct loading of vessels had never been attempted before because of the well founded impression that damage to fixed equipment would result, which is based on the fact that in many ships the hatches do not have sufficient area to permit free passage to packages of large dimensions, with the result that forcing methods in loading have had to be resorted to. That is to say, large packages often became wedged in the hatchway, and when pried loose would drop and shift quickly, setting up strains sufficient to break rigid equipment. As the hatches of the *Feltore* extend across the ship for almost its full width, no difficulty of this nature had to be overcome while loading it directly, and the operation proved to be a complete success.

The 50 locomotives were delivered unassembled to the pier in 200 cars. The car loads were made up of 20-ton locomotive boilers, 14-ton tender tanks, 12-ton locomotive frames, 4-ton cabs, 4-ton drivers and 3-ton cylinders. During the first day 19 of the 20-ton boilers were loaded in seven hours, a cycle being completed in about 22 minutes.

Following usual methods, the ship would have been anchored off shore and the cargo moved from the pier by cranes, loaded on to barges, and from these transferred to the hold of the vessel by the usual lighterage methods.

As the cargo could not be loaded on to barges in less time than is required to load it into the ship, the initial saving by the method of loading directly into the ship is apparent. The time which would be required to transfer the load from the barges to the ship would depend on the location of the ship in reference to the pier and cannot be arrived at definitely. As a comparison, however, it may be said that the estimated time for transferring a 20-ton locomotive boiler from a barge to a ship is about one hour as compared with the 22 min. mentioned. (*Railway Age*, April 18, 1919)

The Status of Industrial Relations

By L. P. ALFORD,[1] NEW YORK, N. Y.

At the Annual Meeting of the Society in 1912, a report was presented by the Sub-Committee on Administration, of which the late James M. Dodge was Chairman and L. P. Alford Secretary, on The Present State of the Art of Industrial Management. This report was replete with information upon the broad aspect of the management problem as it then existed in the industries of the country.

During the seven years which have intervened since the preparation of this report, the question has been studied from many different angles and has come to be viewed in quite a different light from that in which it was regarded when the original report was prepared. In consequence, the Committee on Meetings and Program appointed Mr. Alford a committee of one to prepare the following new report upon the subject for presentation at the Session on Industrial Relations at the Detroit meeting.

This report not only comprises a review of the new aspects of the problem which have recently developed, but also a historical summary of the progressive stages in the development of industrial relations since the period immediately following the Civil War. It has proved to be inevitable that after any great economic disturbance like that produced by the Civil War, or the present period of unrest following the world conflict in Europe, there should be unrest and uncertainty in the field of labor and employment; and it thus seems appropriate at this time to outline briefly the most important transactions which have occurred in this field, beginning with the time of the Civil War and including the situation which now exists, so similar in character, but greatly amplified.

IN the presidential address made to this Society in 1882 is the following remarkable statement of the responsibility of engineers in solving the problems involved in the relations of employers and employees:

> In singular and discreditable contrast with all the gains in recent and current practice in engineering, stands one feature of our work which has more importance to us and to the world, and which has a more direct and controlling influence upon the material prosperity and the happiness of the nation than any modern invention or than any discovery of science. I refer to the relations of the employers to the working classes and to the mutual interest, of labor and capital. It is from us, if from any body of men, that the world should expect a complete and satisfactory practical solution of the so-called "Labor problem." More is expected of us than even of our legislators. And how little has been accomplished.

Dr. Thurston was speaking of conditions as they were a full generation ago, yet his words are as true today as they were then. The world is looking to the engineers for leadership in these matters "and how little has been accomplished."

The topic of industrial relations is so complex and far-reaching that any treatment within the space of a professional paper must of necessity be restricted to certain aspects of the problems. So in attempting to outline the present position of the body of fact that is comprehended in the term "industrial relations," the scope will be limited to a survey of the more important developments of the last thirty or thirty-five years, and to a statement of a few of the more outstanding tendencies revealed by events of the immediate present.

Before we can attempt to outline the status of industrial relations it is necessary to define what we mean by the term. To that end this statement is offered:

> *Industrial relations comprises that body of principle, practice and law growing out of the interacting human rights, needs and aspirations of all who are engaged in or dependent upon productive industry.*

It will be observed that this definition does not include directly the feelings of uneasiness and unrest among industrial workers, but views them as the expression of real, or fancied, rights or needs, and considers strikes and lockouts as but the assertion of the same or similar claims. On the other hand, the definition does include not only the interests of employers and employees who are actually engaged in industry, but likewise of others who are dependent upon productive industry for the satisfaction of some of their needs, or for the safeguarding of some of their rights.

Beginning with about 1880 there were developed and put into use two practices expected to mitigate or help solve the labor difficulties of that time, namely, profit sharing and methods of wage payment intended to give the worker a direct share in the benefits of increased production. At the present time we are seeing another heightening of interest in profit sharing and the widespread installation of the so-called shop-committee system. Thirty years ago and today are similar periods of experimentation in industrial relations.

Although the beginnings of the development of industrial relations took place during the 80's of the last century the situation in industry did not become acute in the United States until about 1905. That date fixes approximately the time when the evils of absentee directorate of large corporations came into prominence. Many of our great industrial consolidations had taken place before 1905 and the owners had put into effect a system of control and management arbitrarily determined in a few of our large cities, principally New York City, while the plants of these corporations were spread throughout the country.

It is frequently stated that the necessity for establishing industrial relations today is the growth of the factory system wherein all personal contact is lost between owner or manager and the worker. While this is true, it does not sum up the entire loss. In the system of absentee directorate there are other evils as well, and these taken together have set up situations where there have been clashes over the rights, needs and aspirations of those who belong to the class of employers and those who form the great group of employers. These losses in fitness for control may be stated in this wise:

a The loss of personal contact and relationship that formerly existed between the master and his skilled workmen and apprentices

b The loss due to the lack of personal knowledge of the work being done on the part of present-day directors and managers

c The loss due to the lack of personal knowledge of the tools and equipment used in production on the part of present-day managers

d The loss of the direct oversight of saving and conserving materials and human effort on the part of present-day managers

e The withdrawal from productive work of the families of the directors and managers

f The loss of equality of living conditions between the families of the directors and managers and the workers.

The effect of these losses in creating a situation where there may be a clash of interest, and failure on each side to understand and appreciate the other, is brought home when we contrast the human relationships in the days of craftsmanship with those of the factory system. In former time the employer or master knew how to do all parts of the work himself, had in fact done so with his own hands, was in personal contact with all of the tools, equipment and materials used in his shop, had complete personal oversight of everything that was done, and held a relationship of almost father to son with his apprentices who, in many cases, lodged and boarded in the master's home and were served by the master's wife and daughters. Not only did the master instruct his ap-

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[1] Chief of Staff, *Industrial Management*. Mem. Am. Soc. M. E.

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prentices in the requirements and skill of the trade, but he likewise set them the example of right living. All of the activities of the master opened to the apprentice as he became able to exercise them. There was a complete community of interest between the master and his family, his workmen, their families and his apprentices.

By contrast, in American industry today far too often the owners and directors live hundreds and thousands of miles away from the workers in their plants, under entirely different conditions, as varying as New York City and a Massachusetts mill town or a Middle-West factory community. All exact knowledge one of the other is lacking, there is no community of interest or purpose, and no assurance that a policy determined upon in the directors' room will meet the needs and rights of the workers in some far distant locality.

It is the creation of this situation of absentee directorate that has done much to focus attention upon the necessity of developing a body of principles, practice and law to satisfy the needs and safeguard the rights of all who are engaged in or dependent upon American industry.

Examination reveals six major lines of development amid the various methods, plans and systems that have been tried in seeking to work out better industrial relations. These are:

a Profit-sharing plans
b Methods of wage payment
c Methods and laws to reduce the hazards in industry and mitigate the effects of injuries and also of occupational diseases
d Employment management
e Declaration and enforcement during the period of war of three rights of workers, namely, collective bargaining, restricted hours of labor and the living wage. Declaration of these same rights and others in the Treaty of Peace.
f Systems for mutual or joint control by employers and employees.

A controlling reason for considering these six lines of development is their actual or promised permanence and widespread acceptance and application. For this same reason it does not seem pertinent to the purpose of this paper to devote space to welfare methods, industrial betterment, suggestion boxes or systems, shop gardens, factory bands, dances, minstrels, glee and athletic clubs, employees' loans, benefit associations, pensions and many other activities that properly classify under our definition of industrial relations. Without doubt successful applications of every one of these activities can be mentioned, and likewise, without doubt, experiences can be pointed out where they have had a beneficial effect in promoting satisfactory conditions and assisting to develop a "spirit of the organization." It is more than likely that many of these activities will always find a place in industry, but none of them seem to be a major line of development, and in fact all classify under welfare work or industrial betterment, which have fallen into disrepute because of the motive of charity or paternalism that has inspired them in many places.

The element of failure in all these agencies is the lack of removal of the fear of unemployment. For the fundamental cause of industrial unrest is the dread of losing the opportunity to work and thereby secure the necessities of life, or of being cut off from deserved promotion.

Profit Sharing

Profit sharing has been mentioned as one of the lines of development that become prominent during the period ending in 1889. A few of these were mercantile establishments, but all were large employers of labor.

Not only is there reason to believe that these attempts were inspired by conditions of industrial unrest, but there is direct testimony to this effect in two cases. The Globe Tobacco Company, of Detroit, Mich., entered into an agreement in regard to its profit-sharing plan in 1886 with the district board of the Knights of Labor; and the plan of the H. O. Nelson Company, of St. Louis, Mo., which was announced on March 20 of that year, was an outgrowth of the great railroad strike, strikes in the building trades and the movement for the eight-hour working day.

Within the past six months a number of large industrial plants in this country have announced or put into effect profit-sharing plans, so we seem to be having a repetition of what took place during the 80's of the last century.

It is worth while to point out that although profit sharing was put into effect in a number of American industries a generation ago, it has never had widespread adoption. This fact may cause us to question its effectiveness as a promoter of good industrial relations. Several reasons are recognized for this situation: Payment of gains under profit-sharing plans are deferred and so lack an immediate appeal; the gains do not come directly nor entirely from the efforts of the workers, but are dependent upon the hazards of the enterprise; the amount distributed to any individual worker is equivalent to an increase of only a few cents an hour for the year; the amount shared by each person among the owners and managers is many times greater than that received by each workman.

Plans for stock participation have the same purpose and value as those for profit sharing.

Methods of Wage Payment

The pioneer work that has since yielded the science and practice of industrial management was performed during this same period of industrial unrest, that is, from 1880 to 1889. During this decade Mr. Henry R. Towne presented two papers before this Society that have been frequently referred to as the beginnings of the literature of industrial management. The first was read in 1886. In it Mr. Towne called the attention of his fellow-engineers to the need of a study of the financial and profit-making aspects of shop management. He urged his associates to become "economists" because the engineer is one who essentially effects economy. His second paper was presented in 1889 and in it was described a gain-sharing plan that Mr. Towne had applied in his own shop. The object was to enable his employees to share the profits of the business depending upon gains in efficiency as shown by careful accounting.

Influenced by his study of the epidemics of strikes during the same decade, Mr. F. A. Halsey originated his premium plan of wage payment that was disclosed to this Society in a professional paper read at the Providence meeting in 1891. A recent letter written by Mr. Halsey to the author mentions the activities of the Knights of Labor and the great street-car strike in New York City as two of the events that influenced him to study the possibility of some form of wage payment that would reward the worker for increased effort and production.

This same decade was the period of the work of Dr. Frederick W. Taylor, which later on gave to this Society several papers outlining his system of shop management. It will be recalled that a part of his methods was a system of wage payment known as the "differential system."

Since that time several other methods of wage payment have been originated and developed, so that today we recognize some half a dozen that have more or less extensive application. Each one has been developed with the purpose of improving the relationships between employer and employee in regard to the division of the earnings and profits of industry, or to provide an extra reward for extra productive effort.

The "Safety-First" Movement and Workmen's Compensation

About 1910 American juries began to award large sums in suits for personal damages, where the plaintiff had been injured by machinery or otherwise in industry. Employers turned to liability-insurance companies to defend these suits and settle with their employees, thus bringing an outside party between them and their workers. Appreciation of the hazards in industry and the hardships endured by incapacitated workmen and their families, not only during the period of recovery from the injury itself but perhaps throughout the life of the wage earner due to decreased

earning power, gave rise to the "safety-first" movement and the enactment of workmen's compensation laws.

It is interesting to note that the safety-first movement was fostered largely by men residing west of Pittsburgh, many of whom were in the employ of large corporations where directorates were in New York City. Furthermore it was from the outset a young man's movement. Here and there a few progressive firms paid generous compensation voluntarily before laws were passed making this practice compulsory. Mr. John L. Henning instituted such a plan in 1904 in a mining operation in Louisiana of which he was chief engineer. This is the earliest attempt of this kind in the United States that has reached the author's attention.

In the enactment of compensation laws the rights and needs of the community were recognized. An entirely different view of the legal relationship of employer and employee was taken than that which had existed before, and which was summed up in the expression "master and servant." The responsibility for the injuries was placed squarely upon the industry through the employer, and in boards and commissions, machinery was set up to make sure that employees would receive the compensation to which they were entitled. The leader among the states having compensation laws is New Jersey and the effective date was July 4, 1911.

But the safety-first movement has yielded much more than this group of legal enactments. There has grown up a large body of practice in regard to safeguarding machinery and working spaces, establishing and operating first-aid rooms and factory hospitals, toward improving the heating, ventilation and sanitary conditions in factories, removing or mitigating conditions tending toward occupational disease, providing medical, dental and nursing service for the families of employees, establishing medical examinations before employment and at stated intervals thereafter, teaching personal hygiene to employees and their families, and, in fact, a complete new outlook in regard to the health and physical welfare of all who are engaged in industry. Through it all there has been a moral motive.

The movement has also brought into being two strong organizations, the National Safety Council and the Workmen's Compensation Bureau. In addition there is an association of physicians who are engaged in industrial practice.

The American Society of Mechanical Engineers has contributed to this development through taking the initiative in preparing several safety codes or standards. It is estimated that the safety-first movement of the past ten years has reduced the number of annual fatal accidents in the United States from 35,000 to 22,000 with a corresponding lessening of maiming and disabling accidents. This line of development is the most significant of all from the viewpoint of the interests of the community.

Employment Management

Since 1916 there has come into prominence what is now recognized as a new profession in industry, that of employment management. It comprehends in its broadest interpretation the establishment of all policies and direction of all of the functions having to do with personnel. It has taken over, expanded and developed the former work of hiring and discharging, has sought to reduce labor turnover and has fostered and directed those activities which are usually comprehended under the term welfare.

The oldest organized employment department of which the author has knowledge has been in operation about nineteen years in the plant of the B. F. Goodrich Company, Akron, Ohio. In 1907 Mr. H. F. J. Porter in a discussion of a paper presented before this Society called attention to the evils of labor turnover and outlined some methods that he had taken for its reduction. In 1914 Mr. Magnus W. Alexander presented a striking address before a convention of the National Machine Tool Builders' Association in which he gave statistics gathered from some twelve metal-working plants revealing the tremendous amount of the turnover of labor and its excessive cost. A small group of men in and around Boston, Mass., worked on this problem of employment for a number of years and as early as 1910 organized the Boston Employment Managers' Association.

But the movement did not gain headway until about 1916 when it was ready for the truly marvelous expansion that has taken place during the period of the war. No other line of development in industrial relations has had the rapidity of growth of employment management. But the impelling motive has not been entirely that of fostering good industrial relations, although that result has come in many cases where the work has been well done. The major reason in the minds of most industrial executives in establishing employment departments has been to secure employees during the period of labor scarcity and to find out why men leave. Another impetus to the movement came through the action of the United States Government in insisting that such departments should be installed in plants manufacturing munitions, war supplies and ships. To meet the demand for trained managers a number of colleges and universities established six-week courses in employment management under the direction of the War Department. Since the signing of the armistice several of these have been modified and put on what will probably prove to be a permanent basis.

Declared Rights in Industrial Relations

As a war measure President Wilson by proclamation created a National War Labor Board to establish principles and policies in regard to the employment and utilization of labor during the period of war, more particularly in war industries, and to set up machinery for considering and adjusting grievances. At the outset this Board declared three rights of labor: The right to organize and bargain collectively; the right to a limited number of hours of labor; the right to a living wage. The Peace Treaty written at Versailles recognizes these three rights and several other principles that are of "special and urgent importance." The recognition of these rights is a great step in the development of industrial relations, and they can never be abrogated in American industry. The same situation is reflected in British conditions as shown by the report of the Employers' Industrial Commission of the United States Department of Labor.

Mutual or Joint Control

The sixth major line of development has to do with control in industry. Students of the present condition of unrest have pointed out that the fundamental is a "struggle for control," the opposing forces being the owners and the workers. The expression "industrial democracy" is frequently used as describing a state that is about to come, or is now being ushered in. The parallel between our political democracy and the expected industrial form is sometimes put in this wise: The slogan that gave birth to this nation and brought our political democracy was, "No taxation without representation." The parallel slogan expressive of the movement to bring industrial democracy is "No control without representation."

The method that is being followed to put this ideal into practice is the shop committee. It is a new development. The oldest was put into effect in 1903 and most of them were started in 1918. Bridgeport alone has 44 plants where this system is in force. The plan installed by Mr. H. F. J. Porter in 1903 in the plant of the Nernst Lamp Company in Pittsburgh was described by him in an article published in *The Engineering Magazine* in August 1905. The shop committee was made up of secretly elected employees under the chairmanship of the shop superintendent. Conditions in the plant that might be bettered for the employees were discussed, and the committee evidently functioned as a safety-first committee as well as a representative shop committee.

Without doubt the success of the safety committees, with which there has been some six or seven years of experience, has paved the way in many plants for the representative shop committee. In fact, a prediction of this development is found in a paper presented before this Society in 1915 written by Mr. W. H. Cameron.

A general classification of these shop committee plans yields three types:

The first sets up an organization roughly paralleling the Cabinet, Senate and House of Representatives of the United States

Government. The Cabinet may consist of some or all of the directors or higher executives of the plant. The Senate may consist of all or a portion of the foremen, while the House of Representatives is a body secretly elected by the employees.

A second type divides the workers in the plants into divisions, each having a definitely determined and equal number of employees, not necessarily defined accord to craft or occupation. Any one division may include employees from several trades and doing varying kinds of work. Each division secretly elects its own representative, and these representatives coming together form the shop committee. This plan is simple, but is not adapted to industries where there is a high degree of organization or where the workers naturally divide into a series of recognized trades.

The third plan is the one adopted by the National War Labor Board and installed under its direction in a number of plants making war materials. Its essential features are outlined in the following official statement of procedure for election:

> Shop committees shall be selected to meet with an equal or lesser number of representatives to be selected by the employer. Each department or section of the shop shall be entitled to one committeeman for each one hundred employees employed in the department or section. If in any department or section there shall be employees in excess of an even hundred, then an additional committeeman may be elected providing the additional employees beyond the even hundred shall be fifty or more; if less than fifty no additional representation shall be allowed. As an example: In a department or section employing 330 men, three committeemen will be elected; in a department employing 375 men, four committeemen will be elected.

In plants where shop committees have been in operation for some time, a wide variety of topics has come up for discussion and determination. One grouping lists some forty-two different kinds of matters, of which only one was wages. The plans are too new, however, to estimate the extent of the effect they may have in developing good industrial relations. But a sufficient amount of experience has already been accumulated to indicate that the application of the ideas of joint consideration and control on the part of employers and employees will produce favorable results. To reach a workable basis, the employer must voluntarily limit his own authority and agree to conduct his business by the rule of reason and even-handed justice as interpreted by the representative shop committee that he may set up. The plan seems to restore, so far as possible in a large-scale business, the simple and effective relationship that used to exist between the master and skilled workman, and which largely exists even today between the small employer and his half-dozen employees.

A rather more formal mechanism for establishing representation in industry is the protocol system worked out in the coat and suit trade in New York City, and which has been applied in a few other instances in similar trades.

From one viewpoint the rapidly developing movement to put shop committees into effect in the United States is a confession on the part of employers and those who have the responsibility for industrial enterprises that they have already lost some of their control. Under such condition there is a readiness to experiment. From another viewpoint it is an earnest attempt to find a basis of democratic coöperation in the control of industry.

A parallel movement has taken place in Great Britain leading to the proposal to establish Industrial Councils through which the British Government may promote effective coöperation between the organized employers and workers, believing that representative government in industry will foster good relations.

Development of Motives

After having sketched these six lines of development in improving industrial relations and in building up a great body of principle, practice and law, it is wise to examine some of the predominating motives.

One that came into play early and brought to the front those practices and activities summed up under the headings welfare work and industrial betterment was the motive of altruism. The successful manufacturer, taking the part of the autocratic benefactor, enjoyed the swelling of the heart and feeling of personal gratification that came to him when he arranged for the spending of money to provide conveniences and benefits for his employees, as bathrooms, restaurants, flower gardens, reading rooms, rest rooms, and the like. But workers are quick to resent favors if they are substituted for justice, and the welfare movement as such has very properly been discredited and has practically disappeared, although many of its activities have been retained but inspired by a different and proper motive.

The safety-first movement from its inception was influenced by engineers who saw the essential economy in preserving the life and limb of the workers. The employers translated this engineering economic viewpoint into the commercial motive "it pays." Selfish though this was and is, nevertheless it was neither charitable nor paternalistic, and because the movement had a firm basis in sound industrial economics and in morals it has met with deserved and widespread success.

But even this engineering-commercial motive is inadequate to provide the impetus for the developing of the industrial relations that we all hope for. It does not comprehend the interests of all who are dependent upon and must be served by productive industry; so many of the leaders of thought on industrial matters have declared and emphasized another motive, saying that it must predominate and prevail, else we will never have the development that we need. This is the one of *service*. A recent magazine article by Mr. H. L. Gantt clearly presents this motive. Once it becomes active we can hope for the working out of a new body of principle and practice in regard to industrial relations that will bring far happier conditions than any we have yet experienced.

Interests in Industry

With this development of motive has been a broadening of the recognition of those who are interested in the proper carrying on of industry itself. In the early days the expression "master and man" or the legal "master and servant" summed up these interests and relationships, but as industry developed and the clash of rights, needs and aspirations became apparent the familiar term became "capital and labor," used more particularly to denominate antagonistic forces. In fact, this term is used very generally at the present time, although it has been pointed out that there can be no conflict between capital as such and labor, for we cannot conceive of a man fighting with accumulated wealth represented in the physical means of production. So, to clarify thinking, some authors have insisted that we should use the term "capitalists and laborers" instead of capital and labor. Point is given to this contention by a quotation from a speech delivered by President Lincoln before the Wisconsin Agricultural Society in 1859: "Labor is prior to, and independent of, capital —in fact, capital is the fruit of labor, and could never have existed if labor had not first existed. Labor can exist without capital, but capital could never have existed without labor."

The next development of interests brought consideration of the needs and rights of the public, which depends upon the proper carrying on of industry for much of its well-being. This thought brought a new grouping—"capitalists, laborers and the public." Quite recently in studies of industrial relations some writers have included five parties, namely: The capitalists who supply the materials and means for production; the laborers who supply productive capacity; the managers who provide direction and control; the community in which the industry is located and upon whose operation its welfare to a certain extent depends; and the public that purchases the articles and goods produced.

There is more than ample reason for including the interests of the community and public in any such classification. The laws regulating the hours of labor for women and children, for the elimination of hazards in industry, and for compensation for industrial accidents are but one expression of the rights of the community as well as the worker in the operation of industry.

Before justice can be framed in the form of law there must have been developed a body of general principles. It is evident that the principles underlying industrial relations are now in a process of rapid formulation. It is probable that before long our courts will have to pass upon an increasing number of industrial-

(*Concluded on page 556*)

Production of Liberty Motor Parts at Ford Plant

By W. F. VERNER,[1] DETROIT MICH.

The Liberty motor was designed for quantity production and consequently many interesting methods were developed to speed up the work. Those employed in producing cylinders in six operations are particularly unique and this paper gives a brief account of the process as carried on at the Ford Motor Company's plant at Detroit during the period November 1917 to December 1918. A description is also given of the twenty-one operations necessary to produce connecting-rod crankshaft bearings, and in the complete paper will be found details regarding the method of installing crankshaft bearings in the upper and lower halves of the crankcase.

ON November 22, 1917, the Ford Motor Company entered into a contract with the United States Government to build 5000 Liberty motors. The contract was accepted at a time when Ford cars were being manufactured at the rate of 3500 per day and to change over from their production to that of Liberty motors was by no means a minor undertaking. The manufacture of Liberty motors differs in many essentials from the manufacture of the ordinary type of motor used for automobiles, and of the 14,000 tools used on Ford car production only 987 were adaptable to the production of Liberty motors.

It was estimated that 350,000 sq. ft. of floor space would be required to produce 50 Liberty motors per day of eight hours. The ultimate space required was 550,000 sq. ft. As no floor space was available, this necessitated the dismantling and removing of several thousand machines and the rearrangement of over 50 per cent of the regular plant equipment. The new arrangement was so made as to allow an entire building for the production of Liberty motors. This permitted the concentration of production and therefore maximum efficiency and production in the shortest time, and since production in the shortest time possible was the great issue, no expense was spared in this shop rearrangement.

The shifting of labor from standard-car production to Liberty motor production was gradual. No labor trouble was experienced as the curtailment in regular products released enough labor for the production of Liberty motors. Table 1 shows the growth in the number of men employed in the Liberty Motor Department.

TABLE 1 SHOWING GROWTH OF FORCE BUILDING LIBERTY MOTORS AT FORD MOTOR CO. WORKS

Date	No. of Men Employed	Date	No. of Men Employed
Nov. 22, 1917	0	Aug. 1, 1918	7,976
Feb. 2, 1918	675	Sept. 5, 1918	9,390
March 1, 1918	779	Oct. 1, 1918	10,653
April 1, 1918	1,550	Nov. 1, 1918	11,288
May 1, 1918	2,450	Dec. 1, 1918	826
June 1, 1918	3,412	Jan. 2, 1919	543
July 1, 1918	5,141		

In accordance with the terms of the contract deliveries were planned as follows:

April 1918	200
May 1918	800
June 1918	1000
July 1918	1000
August 1918	1000
September 1918	1000
Total	5000

This schedule was subsequently revised with instructions from the Government to attain a maximum production of 100 motors per day in anticipation of an order for 7000 additional motors. The schedule was revised to obtain a production of 2500 motors per month by December 1918.

Production was fast approaching the goal when the armistice was signed, as evidenced by Fig. 1, which shows the production of Liberty motors at the works of the Ford Motor Company for the period from November 1917 to December 1918. As is invariably the case in any new undertaking, the production of these motors was retarded by many factors which it was the effort of the engineers to eliminate. Among the predominating ones were the following:

1 Orders for raw material could not be placed immediately on account of incomplete detailed specifications

2 There were many changes. For a period of 14 months, 1013 changes were authorized: March 1918 showing 167, April 109 and May 115; then tapering off to December 1918 which showed only eight changes. These changes represent Government changes and do not include those made by Ford Motor Company in dies, jigs and fixtures, which averaged from three to five for each of the above

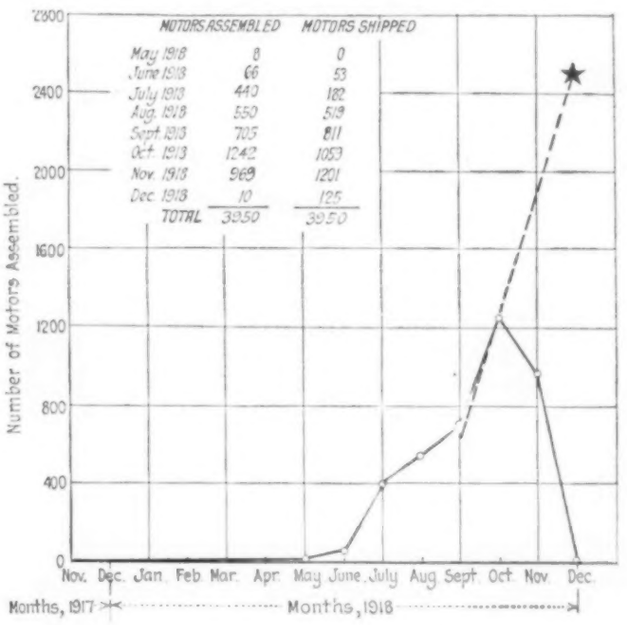

FIG. 1 PRODUCTION OF LIBERTY MOTORS AT THE FORD MOTOR COMPANY'S PLANT

3 Material specifications were constantly revised

4 Shortage of fuel, especially with sub-contractors

5 Railroad embargoes delayed shipment on shop machines and raw materials

6 A-4 priority on shop machinery instead of A-1

7 Lack of acceptable thread gages

8 Lack of actual shop experience by Government inspectors.

The falling off in production in November was of course due to the signing of the armistice. On the day the armistice was signed, the highest mark was reached in the number of motors assembled in one day, namely, seventy-five.

METHOD OF PRODUCING MOTOR CYLINDERS

Several major and important developments were brought about by the Production Department of the Ford Motor Company. First among these was the cylinder forging made from tubing.

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For presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Contributed by the Detroit Section. The paper is here printed in abstract form and copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

This method resulted in an enormous saving when considering the cost of machining a cylinder from a solid forging and also the cost of making a solid forging. The Liberty motor cylinder was forged from a high-carbon steel tube $5\frac{3}{4}$ in. outside diameter, $4\frac{3}{4}$ in. inside diameter by $39\frac{3}{4}$ in. mill length, and completed in six operations as follows:

Operation A—Cut off
Operation B—Close head
Operation C—Form the head
Operation D—Rough-drill bosses for inlet- and exhaust-valve ports
Operation E—Upset and form flange
Operation F—Heat-treat.

Operation A—Cut Off. The tube was heated, at the point at which it was to be cut to about 1200 deg. fahr., in a specially

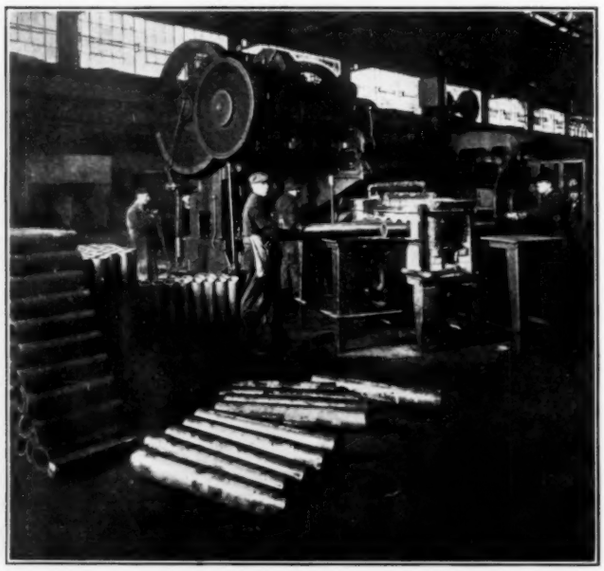

FIG. 2 GAS FURNACE FOR HEATING TUBES—OPERATION A

designed rectangular gas furnace having a series of circular openings along two sides, and through which the tubes were inserted. The capacity of the furnace (Fig. 2) was such that the successive tubes were heated sufficiently for cutting within the time required for the cutting operation. Once started, the operation was continuous with a production rate of 150 tubes per hr. per machine.

Upon removing the tube from the furnace it was placed in the shearing die of a press equipped with a special punch and die. The tube was then fitted with an arbor so constructed that as the punch of the press sheared the outer wall of the tube, the arbor transmitted the shearing power to the lower wall, thus shearing the whole without distorting the tube. The punch and die were set on the press so that the end of the tube was cut at an angle of 19 deg. with the center line of the tube, to the required length of $20\frac{5}{8}$ in. at one side of the angle and $19\frac{1}{8}$ in. at the other side. This angular cut was essential to Operation B.

Operation B—Close Head. It was considered for a long time next to impossible to forge a Liberty motor cylinder from a tube on account of the manufacturing difficulties encountered in closing the head. When the end of the tube to be closed was cut at right angles to the center line, it was found unsatisfactory due to cold shuts or unfused sections in the metal occurring in the center of the dome.

However, by cutting the tube at an angle of 19 deg. with the center line of the tube it was found that the forming dies could be so constructed as to cup or draw inward the tube wall, the high or extended portion of the wall causing the converging or closing of the metal to one side of the center line of the tube until, in the final forming of the head, the metal was joined at right angles to the 19-deg. cut (See Fig. 3.) After this operation the appearance of the closed end resembled the common type of explosive shell with the nose portion at an angle of 19 deg. The central portion of the dome is thus formed without a weld and retains to the fullest extent its fibrous strength.

The angular head of the tube was then heated in a furnace similar to the one previously described to about 1900 deg. fahr. preparatory to forming the head so that the point could be used as a part of the boss which later was drilled for an intake or exhaust post.

The die used in this operation was of the double-action type and comprised two semicircular steel jaws, tapered on the upper outside diameter and pivoted in the rear to swing horizontally. A cast-iron locking plate was attached to the blanking foot of the press and tapered to correspond to the taper of the jaws, so that when the blanking foot was in down position the tapered surfaces of the jaws served to lock the tube in position. The interior upper parts of the jaws were bored and fitted with split bushings or bronze bearings to fit the punch. Resting flush normally with the upper surface of the jaw was a semicircular steel supporting band equipped with three guide pins supported on springs.

When the jaws were swung in position around the tube, they formed a steel ring which gripped the tube around the top or heated portion and as the punch descended, the ring slipped down the tube, and the supporting springs depressing under the pressure of the punch thus prevented the tube from bulging when the punch closed in the head. The punch was designed so that the dome was drawn to a point 19 deg. to one side of the center line of the tube, as previously described.

Operation C—Form the Head. This operation was performed on a press (Fig. 4) provided with a specially designed punch and die. To serve as a die, a bolster or base plate was mounted on the bed of the press. The base plate was bored in the center to re-

FIG. 3 PRELIMINARY FORMING OF THE CYLINDER HEAD—OPERATION B

ceive the shank end of an upright cylindrical locating arbor and counterbored to receive a thrust plate. Two sections made up the arbor, the lower of which was made of soft steel bored to receive the hardened-steel tip or top section. The top section tapered slightly inward at the extreme end and the top surface was curved to properly form the dome or head of the cylinder.

Horizontal sliding jaws around the locating arbor were held open by springs and operated by cams attached to the ram of the press. The upper interior portion of the jaws was shaped to form the expanded area for the combustion chamber. When the jaws were closed by the cams, they fitted snugly around the punch.

As the ram descended, the cams attached thereto forced the jaws together so that as the punch pressed down the head of the tube on the arbor it formed the valve-port and spark-plug bosses and the jaws formed the expanded area for the combustion chamber. On the back stroke, the jaws were forced apart by the springs as soon as the pressure of the cams relaxed. In case of adhesion to the cylinder, a wedge attached to the ram and operating between the two ends of the jaws breaks the adhesion on the back stroke. A knock-out sleeve located about the base of the arbor and operated by an arm beneath the bed of the press on the back stroke was carried upward and loosened the cylinder on the arbor. Production on one machine totaled 150 per hour.

Operation D—Rough-Drill Bosses for Inlet- and Exhaust-Valve Ports. The cylinder was held in a trunnion fixture attached to a drill press so that the center line of the valve port swung in line with the spindle. The cylinder was located by using the valve-port bosses.

Operation E—Upset and Form Flange. These operations were performed on a 5-in. forging machine in one heat-treat on two separate dies. The die used for the first portion of the operation (upset) comprised two horizontal sliding steel jaws operated by cams and bored at both ends to fit tightly about the body of the cylinder. At the middle the jaws were undercut or recessed so that in the upsetting the metal would so flow as to form a heavy ring of metal at the section at which the flange was to be located on the cylinder. The punch was in the form of a mandrel with a shoulder which fitted the closed jaws and which on striking the bottom of the skirt or open end of the cylinder forced the heated metal to the proper upset dimensions about the mandrel and in the recess of the jaws.

The die employed in the second portion of the operation (form flange) was of the same type above described, with the exception

FIG. 4 PRESS USED IN FINAL FORMING OF CYLINDER HEAD—OPERATION C

that the jaws were counterbored at the entrance end to the forged flange dimensions, instead of being recessed in the middle. The punch consisted of a mandrel with a shoulder surrounded by a sleeve which extended beyond the shoulder. The sleeve fitted the closed jaw of the die and the inside extended portion upset the metal by pressing it against the die, thus forming the flange. The sleeve was provided with two vent holes permitting gases that might be formed during the forging to escape.

In operation the skirt of the cylinder was first heated to about 1900 deg. fahr. in a furnace, then dipped in water to a depth of about 1½ in. This cooling was done to form a ring of hard metal at the bottom of the skirt for the punch to act upon. The cylinder was then placed in the forging machine and the flange made. Production totaled 85 per hour on one machine.

Operation F—Heat-Treat. The completed forged cylinder was placed in a large rectangular heat-treating furnace and heated to a temperature of 1525 deg. fahr. and then quenched in a brine solution. After quenching it was heated in an annealing furnace to a temperature of 1125 deg. fahr. and cooled in air. Brinell test was 217-255. This heat treatment left the cylinder ready for the machine operations.

METHOD OF MACHINING CONNECTING-ROD CRANKSHAFT BEARINGS

Next in importance to the method just described of producing Liberty motor cylinders was the development of a special process of making bronze babbitt-lined bearings for the crankshaft end of

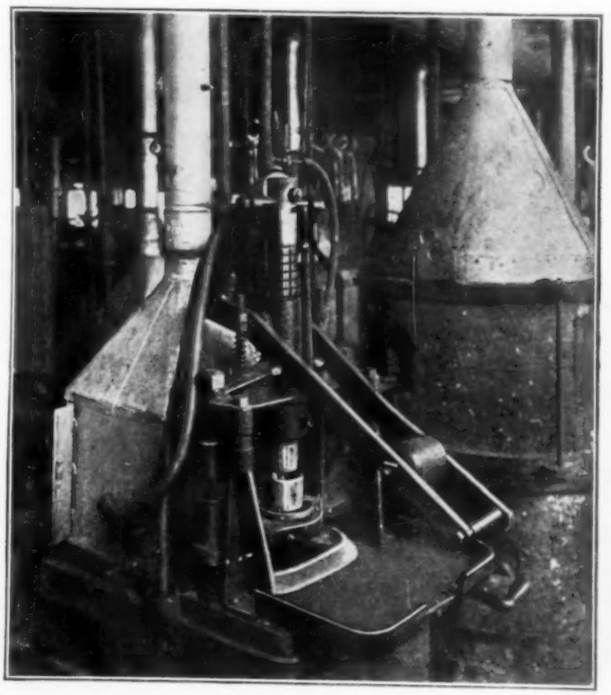

FIG. 5 BABBITTING MACHINE—OPERATION 4

connecting rods which would stand up under the Government's 50-hour test. The method comprised 21 operations, as follows:

1 Rough-drill closed end
2 Rough- and finish-bore bronze and face one end
3 Turn outside diameter to fit babbitting fixture and face one end
4 Babbitt
5 Cut off gate, rough- and finish-bore babbitt
6 Finish-turn outside diameter to 3.095 in. and face ends to length
7 Press in broaching ring
8 Broach hole to 2.4275 in. in diameter
9 Press out of broaching ring
10 Grind outside diameter to 3.075 in.
11 Cut in halves with 3/64 in. saw (2 on)
12 Close in
13 Swage
14 Finish-mill the parting line
15 Face ends to length
16 Fillet both ends
17 Cut two grooves for forked-end rod
18 Drill and ream dowel holes in lower half bearing only
19 Cut two ⅛-in. semicircular oil grooves on the parting line
20 Cut twelve oil pockets in both halves
21 Burr.

Operation 1—Rough-Drill Closed End. A 21-in. drilling ma-

chine was used in this operation, which was necessary only on castings where a thin web of metal entirely closed one end.

Operation 2—Rough- and Finish-Bore Bronze and Face One End. This operation was performed in a 12-spindle 14-in. multiple machine. The bushings were gripped in a chuck and bored at the rate of about 80 per hour.

Operation 3—Turn Outside Diameter to Fit Babbitting Fixture and Face One End. A 12-spindle 14-in. multiple machine was also used for this operation. The bushings after boring were clamped on special arbors and the outside diameter turned to fit babbitting fixture.

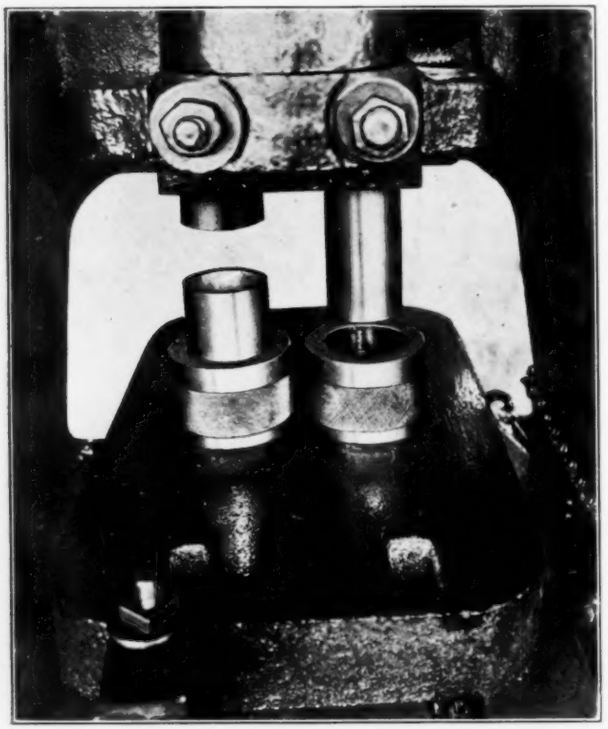

FIG. 6 PRESSING IN BROACHING RING—OPERATION 7

Operation 4—Babbitt. The equipment required for this operation consisted of acid vats, tinning furnaces, die-casting machines with water-circulating systems, a furnace large enough to supply a unit of four die-casting machines with molten babbitt and a compressed-air outfit to use with the gas furnaces.

The bushing was first dipped into a flux made proportionately of 11 lb. sal ammoniac, 9 lb. zinc chloride, 6 qt. muriatic acid and 13 qt. water. The hydrometer reading was 23 to 25 deg. B.

Before placing the bushing in the specially designed die-casting machine to be babbitted it was immersed in the molten tin. The die-casting machine, Fig. 5, consisted of a rectangular plate mounted on suitable legs or base, having a cored hole for receiving a crucible containing the metal; a crucible with suitable rim having two bosses on which were fitted bearings for a pump-lever shaft; a pump fastened to two bosses of the rectangular plate for forcing the metal through a nozzle into the die proper; and a fixture mounted on the plate straddling the pot for casting the bearing.

The fixture for casting the bearing was made up of a circulating-water-cooled mandrel or arbor sliding vertically in a housing. This housing was secured to two side-support brackets which were bolted to the plate. The lower die holder carrying the die spans the crucible and slides vertically on guide pins. Springs received the weight of the holder in suspension. Just inside of the guide-pin bearings and screwed into the holder were two suitable rods which extended through the housing. The housing was drilled and counterbored to receive rods and springs. The lower die holder in its normal or loading position was suspended on the springs so that the opening or gate of the die was slightly above the nozzle of the pump.

For babbitting, a tinned bushing was inserted in the lower die and the water-cooled arbor was moved downward until stopped by the arbor stripper ring, clamping on the upper end of the bushing to be babbitted and the gate end of the lower die on the pump nozzle. The movement of the arbor was controlled by an upward movement of the hand lever. While holding the arbor firmly in position with one hand, the operator with the other hand pulls upward on another hand lever attached to the pump lever, thereby forcing the molten babbitt from the pump cylinder through the nozzles and into the bushing.

The metal was allowed to set for about 30 sec., when the pump-control lever was pushed downward. The piston of the pump upon its return uncovers ports permitting molten metal to flow into the cylinder preparatory to another casting. Simultaneously the arbor-control lever was thrown downward, assisted by the weighted end, causing the arbor stripper ring to strike violently against the lower face of the arbor housing and thereby stripping the babbitted bushing from the arbor. This upper movement of the arbor allowed the lower die holder to regain its normal position

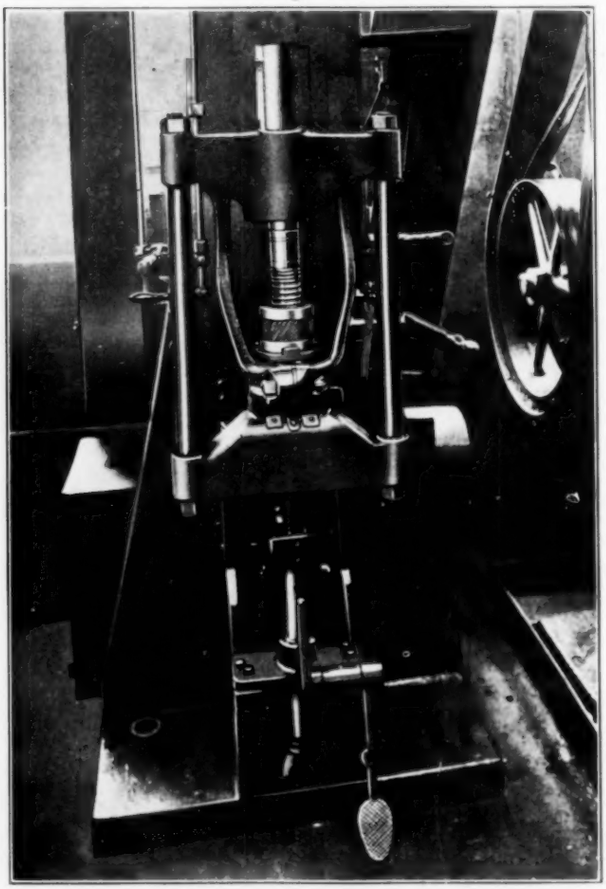

FIG. 7 SPECIAL BROACHING MACHINE—OPERATION 8

and severed the connection between the lower die and pump nozzle, which assured the bushing sticking to the water-cooled arbor and not becoming gate-anchored to the lower die. The thickness of the babbitt wall at the top for best results in babbitting was 3/32 in. and for the bottom 3/16 in.

Operation 5—Cut Off Gate, Rough- and Finish-Bore Babbitt. Geared-head screw machines were used for this operation. The bushing was held by a three-jaw clutch; an ordinary cut-off tool held in the tool block of the cross-slide was used for cutting off the gate, and a boring bar with two cutters (one for roughing and one for finishing) was mounted in the turret for boring hole to proper diameter, with an allowance for broaching.

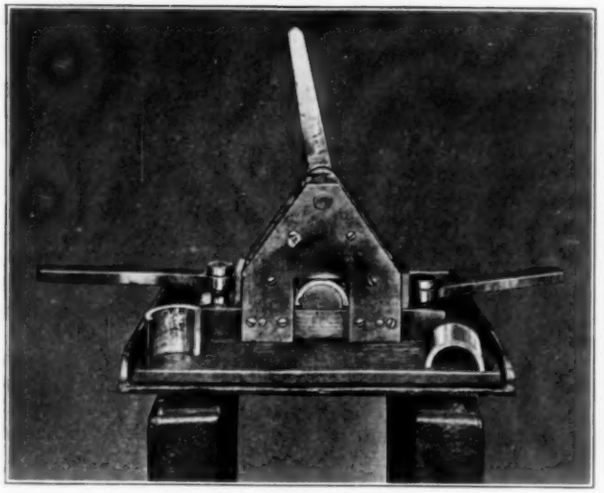

FIG. 8 MACHINE FOR BENDING BEARINGS—OPERATION 12

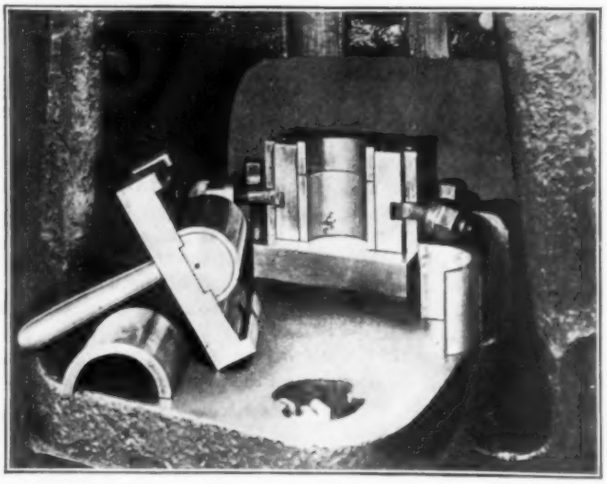

FIG. 9 UPSETTING OF BEARINGS TO FINISHED DIMENSIONS—OPERATION 13

Operation 6—Finish-Turn Outside Diameter to 3.085 In. and Face Ends to Length. In this operation 14-in. x 4-ft. lathes with back-arm attachments were used. The bushings were held on an expanded arbor, which was held in the spindle of the machine. A cutter mounted in the tool block of the lathe cross-slide turned the outside diameter to fit the broaching ring. The back arm carried a tool block with two cutters spaced to face the bushing to its proper length.

Operation 7—Press in Broaching Ring. For this operation (see Fig. 6) a bolster plate with two holes bored large enough to allow the bushing to drop through and counterbored to suit outside diameter of the broaching ring was strapped to the bed of a press. In the ram of the machine were carried two cylindrical punches slightly smaller in diameter than the outside diameter of the bushing but differing in length.

In operation a ring into which had been pressed a broached bushing was placed in the counterbored hole under the long punch and a bushing that was not broached was slightly entered into an empty ring and placed under the short punch. When the press was tripped, the long punch forced the broached bushing out of the ring and the short punch forced the bushing, which had not been broached into the ring.

Operation 8—Broach Hole to 2.4275 In. Diameter. A special broaching machine, Fig. 7, was designed for this operation. The legs were removed from a No. 1 Knowles key-seater and the body complete with gears, rack, slide, etc., was bolted in a vertical position to a special base casting. An upper guide of cast iron, with a hardened and ground steel bushing for the broach-holder quill was dovetailed to the ways of the machine. Below this upper guide was the extended work-holding bracket (a part of the bed of the Knowles keyseater) which carried the work holder. This work holder was a hardened steel bushing ground on its outside diameter to fit the hole in the bracket and counterbored to fit the broaching ring. On the special base casting below the work-holding support was bolted the lower guide, a gray-iron casting with a hardened bushing ground to fit the broach holder. The broach holder was a long tool-steel bar hardened and ground on one end to fit the guide bushings and on the other end to fit the holes in broach and broach-holder quill.

The foot-pedal bracket was bolted to the base of the machine and was bored to fit the broach holder to which it served to guide and keep in alignment. Between the lower guide casting and the foot-pedal bracket was disposed a collar firmly fastened to the broach holder, and attached to this collar was a yoked lever. This lever was so fulcrumed that the weight of the broach was just slightly more than counterbalanced by a cast-iron weight which insured the broach end of the holder being piloted in the quill when the broaching was being done. A hand lever with lift rods was attached to the yoked lever to control the loading.

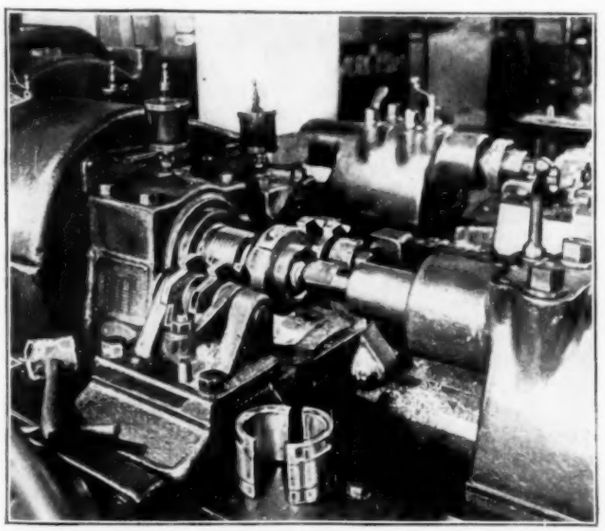

FIG. 10 METHOD OF CUTTING GROOVES FOR FORKED-END ROD—OPERATION 17

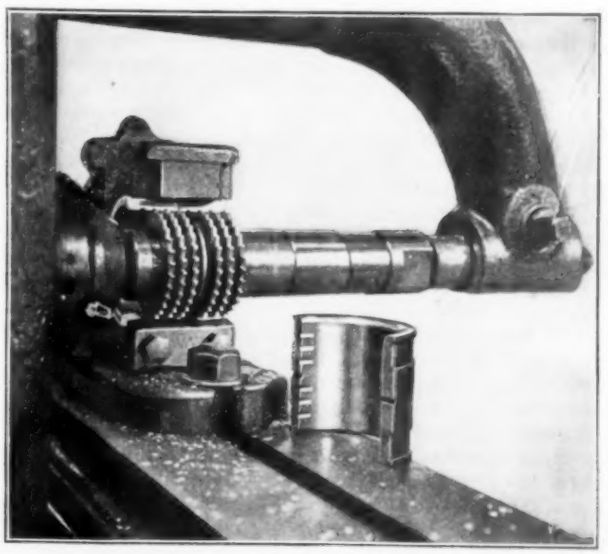

FIG. 11 METHOD OF CUTTING OIL GROOVES—OPERATION 20

The broach had eight cutting edges varying in size from 2.422 in. diam. to 2.4273 in. diam. In addition to the cutting edges, the upper end of the broach had three burnishing surfaces, the diameters of which were 2.4274 in. The broach was 5 in. long and had a hole ground to 1.625 in. diam. to fit the end of the broach holder.

In operation the keyseater functions normally, with the exception that the down (or what would be the return) stroke of the ram is utilized for pushing the broach through the work. The hand lever controlling the broach holder is pulled down until the latch on the foot lever engages the top of the collar on the broach holder. This operation holds the pilot end of the holder and the broach-holder quill apart, allowing the broaching ring containing the work to be mounted in place. The broach holder was then allowed to ascend until the end of the holder protruded enough to allow slipping on the broach, and then further until its end was piloted in the hole of the quill. The machine was then tripped and the broaching was done on the downward stroke of the slide carrying the quill, the broach being forced through the work by the pressure exerted on descending quill. This downward stroke was carried far enough to allow the foot-lever latch to engage the collar on the broach holder automatically. The machine was reversed, disengaging the quill and the broach holder. The broaching ring containing the work was then lifted out and the broach was removed from the holder, leaving the machine ready for the next operation.

Operation 9—Press Out of Broaching Ring. This operation has been previously described under Operation 7, and is shown in Fig. 6.

Operation 10—Grind Outside Diameter to 3.075 In. The bushing was ground between centers on a 6 x 18-in. plain grinder. A split hardened steel ring ground on its outside to a diameter of 2.4275 in. was inserted in the bushing and a hardened arbor ground with a slight taper was in turn inserted into the split ring, the hole of the latter being ground tapering to conform to the arbor. A light pressure applied to the end of the arbor expanded the ring sufficiently to firmly hold the bushing for grinding.

Operation 11—Cut in Halves with 3/64-in. Saw (2 on). This operation was done on a plain milling machine with an indexing type of fixture. The work-holding arbor of the fixture was made long enough to accommodate two bushings. The bushings were clamped on the arbor with a "C" washer and stud bolt. A common 3/64-in.-wide milling cutter was used.

Operation 12—Close In. After being cut in half, the bearings were bent to decrease their diameter so as to allow their fitting easily into the swaging fixture used in Operation 13. The bending fixture, Fig. 8, was made with a semicircular arbor bolted to a base plate. A housing with three cam-lever slides was fastened to the base plates. Openings in both sides of the housing allowed for the insertion of the bearing over the arbor. The top cam lever clamped the work in position and the side cam levers closed in the bearing the necessary amount.

Operation 13—Swage. This operation, which was performed on a press, was the keystone operation in the successful production of accurate bearings, as the set given them insured their holding the shape of the master forms.

The fixture, Fig. 9, comprised a hardened and ground steel base plate fastened to a hardened steel form. Two eyebolts were held by pins in each side of the form. These parts assembled formed the female section and were fastened to the bolster plate. The male section was made up of a half-round arbor of hardened steel on the clamping plate, the joining surfaces of which were also ground. Two slots in each end of the clamping plate allow the eyebolts to hold the two sections together. A tongue-and-groove construction on the joint surfaces of the sections kept them in alignment. A filler piece made of hardened steel and ground to the finished bearing dimensions was used to take the flow from the ram of the press. A hardened-steel cylindrical punch with a flat-ground bottom surface was fitted into the ram of the machine.

In operation, a half-bearing with a filler piece on top of it was clamped between the male and female section of the fixture; the press was then tripped and the cylindrical punch on descending struck the filler piece, which projected slightly above the upper surface of the fixture. This upset the metal to the finished bearing dimensions with an allowance on the parting-line surfaces of about 0.003 in. for finish-milling.

Operation 14—Finish-Mill the Parting Line. A plain milling machine on this operation was very satisfactory considering the close limits of plus or minus 0.00025 in. A fixture with a half-round seat or nest bored to fit the outside diameter of the half-bearing was bolted to the plate of the machine. The parting-line surfaces of the half-bearing were leveled by the hinge gage attached to the fixture. The work was clamped with a half-round hardened and ground steel clamp, the curved surface of which was made to fit the inside diameter of the half-bearing. Two plain milling cutters were mounted on the arbor and were so spaced that they straddled the clamping bolt and nut.

Operation 15—Face Ends to Length. A 14-in. x 4-ft. lathe without a tailstock was used for this operation. A hinged clamping ring was used to clamp the work tight on the steel arbor, which was mounted in the spindle of the lathe. Two halves, or one complete bearing, were machined at one setting. A special tool block with two cutters straddling the clamping ring faced the bearing to the proper length.

Operation 16—Fillet Both Ends. The fillet cuts in both ends of the bearing, to clear the radius of the crankshaft pin, was done on 21-in. drill presses. The fixture comprised a circular-shaped base bored in the center to receive a flanged hardened-steel pilot bushing. The outside diameter of this pilot bushing above the flange was made to fit the inside diameter of the bearings and the hole of the pilot bushing was a fit to the pilot of the filleting cutting holder. The half-bearings were clamped in pairs about the piloting bushing by means of two hinged clamps rotating on a pin located in the rear of the fixture. A single formed filleting center was fastened in a slotted holder. The holder was held in the spindle of the drill press with a tapered shank.

Operation 17—Cut Two Grooves for Forked-End Rod. A 14-in. x 5-ft. lathe, Fig. 10, with a special cross-slide arranged with front and back tool blocks, was used for this operation. A stub arbor mounted in the spindle of the machine was made with a flange to serve as a stop for locating the work while clamping with a hinged ring, similar to the one used for Operation 15. The half bearings were clamped on the arbor at one setting. The arbor was provided with a center so that the lathe tailstock could be utilized to stiffen the support of the work under the pressure of the cut. The grooving cutters were of the circular forming type, with six cutting edges. The adjustment of the cutting edges was controlled by the movement of a toothed lever. The teeth of this lever meshed with the teeth in the boss about the center of the grooving cutter. The cutter in the rear tool block was used for roughing, and the front cutter for finishing. Suitable stops were arranged on the cross-slide to control the depth of the cut.

Operation 18—Drill and Ream Dowel Holes in Lower Half-Bearings Only. A two-spindle 14-in. drill was used on this operation. The drill jig comprised a base with side supports, to which was fastened the drilling plate. On the under side of this plate was fastened a locating block formed to fit the contour of the work. A slide disposed between the side supports and actuated by a cam lever served to clamp the work in position for drilling and reaming. Slip bushings were used in the drilling plate, one for the drill and one for the reamer to insure accuracy.

Operation 19—Cut Two 1/8-in. Semicircular Oil Grooves on the Parting Line. This operation was done on a hand miller. The cast-iron fixture supported the work in a semicircular nest and was clamped in place with a strap and thumbscrew.

Operation 20—Cut 12 Oil Pockets in Both Halves. This operation was also done on a hand miller. The fixture, Fig. 11, was made to so clamp the work that the parting surfaces were in a vertical position. The oil pockets were cut on a radius; the cut being 1/32 in. deep at the parting line and running out to the inner surface of the bearing ¼ in. below the parting line. An arbor with six 1/32-in. wide plain cutters properly spaced was mounted in the spindle of the machine and supported by the over arm.

Operation 21—Burr. A No 1 keyseater was used for removing

(Concluded on page 556)

Economy of Arizona Power Plants Using Oil Fuel

By C. R. WEYMOUTH,[1] SAN FRANCISCO, CAL.

This paper treats of the performances of three steam-electric power plants situated in Arizona where load factor and high fuel cost demand economical operation. Tables and curves of operating characteristics are accordingly given and some of the difficulties encountered in practice are enumerated.

IN certain Arizona steam power plants the combination of favorable load factor and high fuel cost has not only necessitated but has also made possible the attainment of high fuel economy, and even in plants where cooling ponds are used for condensing purposes. This paper refers to the performance of three such power plants, namely, those of the Inspiration Consolidated Copper Company, Inspiration, Ariz.; the New Cornelia Copper Company, Ajo, Ariz.; and the Arizona Power Company, Clarkdale, Ariz. These plants embody many similar features. They differ, however, in methods of condensing as cooling ponds are used at the Inspiration and New Cornelia plants, and water from the Verde River at the Arizona Power Company's plant.

The Inspiration plant was designed in the winter of 1913-14. The International Smelting and Refining Company's smelter adjoins the Inspiration power plant site, and the steam generated in wasteheat boilers in the smelters is utilized for the operation of the reciprocating blowing engines, which are designed for about 175 lb. steam pressure. These blowing engines are located in the same power-plant building as the steam turbines, and since the waste-heat boilers are connected to the same steam header as the oil-fired boilers, their steam pressure and the economy of the turbine plant have been limited by the common steam pressure of from 175 to 185 lb. The New Cornelia Copper Company's plant was designed in the winter of 1915-16, and being independent of blowing engines, the boilers were selected for 250 lb. pressure. While a higher steam pressure would have been possible, the remote location of the plant and experience at the date of design led to the lower boiler pressure being selected. The Arizona Power Company's plant was designed in the winter of 1916-17, and has boilers for 250 lb. pressure.

The Inspiration plant is 25-cycle, 3-phase, 6500 volts. The New Cornelia plant and the Arizona Power Company's plant are both 60-cycle 3-phase, 2300 volts. The maximum load at the Inspiration plant was estimated to be 12,000 kw.; three 6000-kw. Curtis turbines were therefore selected, thus giving one spare turbine. For the New Cornelia Copper Company's plant the load was estimated to be 7500 kw., and this led to the selection of two 7500-kw. turbines, one unit being a spare. The Arizona Power Company's plant was designed as an auxiliary to a hydroelectric system, and intended to carry a peak load of 5000 kw. Owing to the quick shipment required, however, a turbine previously ordered for another company, and rated at 6000 kw., was installed, whereas the remaining equipment was selected for a 5000-kw. load.

All three plants have Stirling steel-encased boilers, with Peabody-Hammel oil furnaces, Green fuel economizers, Moore automatic fuel-oil regulating systems, Wheeler surface condensers, Wheeler dry vacuum pumps, centrifugal hotwell pumps, direct-connected exciters, steamer-driven boiler-feed pumps, etc. Superheaters are installed in all plants, specified to give 100 deg. superheat for the Inspiration plant, and 150 deg. superheat for both the New Cornelia and the Arizona Power Company's plants, all measured at the boiler, and at normal rated capacity of boilers. All the plants also have centrifugal circulating pumps, the Inspiration pumps being turbine-driven, and the others motor-driven.

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The nozzles for the cooling pond for the Inspiration Copper Company's plant were furnished by one of the spray pond companies, who also proportioned and designed the pond arrangement. The actual vacuum shown by the operation of this plant, however, has been a disappointment, as a pond of insufficient area was installed. Since the design of the Inspiration plant this detail has been corrected by the addition of cooling towers. The condensate is returned to the oil-fired boilers, and make-up water for the pond is purified by a Booth water softener. A Cochrane hot-process purifier purifies the make-up for the oil-fired boilers if needed, but it is primarily for purifying boiler feed for the waste-heat boilers installed at the smelter. The blowing engines operate at slightly lower vacuum than the turbines, and advantage is taken of this fact to heat slightly the turbine condensate by passing it through the Volz heaters in the surface condensers of the blowing engines.

Cole-Bergman water weighers and Lea recorders are installed for feedwater measurements, for computing the steam supplied from the waste-heat boilers and the steam required by blowing engines, as well as the steam consumption of the turbines. Steam-flow meters are also used for checking purposes. By this means a separate record is kept of the economy of the turbine plant on the basis of operation independent of the blowing engines.

The feedwater for the New Cornelia plant contains from 30 to 50 grains of impurities per U. S. gallon. The water is low in calcium sulphate and carbonate, high in sodium sulphate, and very high in sodium chloride. It is not practicable to purify this water by chemical treatment. The condensate from the condensers is returned to the boilers, and raw make-up water is used for the pond and boiler-feed make-up purposes. Frequent blowing down is required for the cooling pond, as well as for the boilers. Scale is also formed both in the condensers and the boilers, and this requires frequent cleaning, as condenser scale tends to impair the vacuum.

The Arizona Power Company uses Verde River water for condensing purposes, this being taken through a flume at such a point that the pumping head is reduced by gravity flow. The condensate is returned to the boilers, and the raw make-up water is purified in a Cochrane hot-process purifier.

ECONOMY OF INSPIRATION CONSOLIDATED COPPER COMPANY PLANT

Upon the completion of the Inspiration plant it was placed in regular service. The performance of the individual pieces of apparatus was investigated in order to make certain that everything was working to the best advantage, particular attention being paid to the efficiency of boilers, the adjustment of burners, furnaces, and the automatic firing system. A number of uniform load tests were made of boilers for checking purposes, and the results obtained are given in Table 1 and the curves of Figs. 1 and 2. These tests show a fairly high efficiency at rating, and, rather contrary to the usual results obtained with non-casing boilers, a higher efficiency at fractional loads than at rating. The higher efficiency is due to the tightness and the insulating efficiency of the steel casing. As a result of these tests, instructions were given the operators to divide the load equally among all boilers and this, of course, was done automatically by the firing system. The operators, however, were instructed to keep as many boilers on the line at light loads as could be properly fired, maintaining a fire in each of the three burners per boiler; below this load boilers were cut off the line, and only refired when the load again increased.

The curves of Figs. 1 and 2 show the relation between the steam pressure of the atomizing steam and the oil pressure, both

measured in the supply pipes at the individual burner, between the throttle valve and burner. From data obtained from these curves, the steam-to-burner regulator was set to give the proper pressure of atomizing steam, based on the momentary oil pressure.

A complete description of the automatic oil-firing system in use in these plants will be found in a paper by the writer entitled Unnecessary Losses in Burning Oil Fuel, and an Automatic System for Their Elimination, page 797, Vol. 30, of

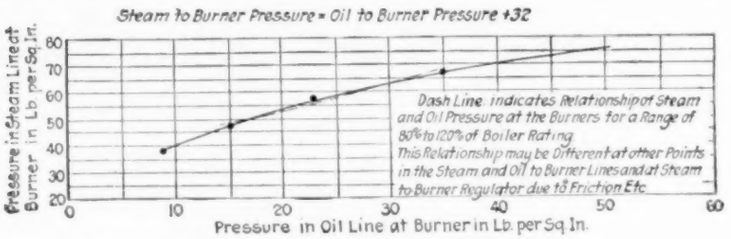

Steam to Burner Pressure = Oil to Burner Pressure +32
Pressure in Steam Line at Burner in Lb. per Sq. In.
Dash Line Indicates Relationship of Steam and Oil Pressure at the Burners for a Range of 80% to 120% of Boiler Rating. This Relationship may be Different at other Points in the Steam and Oil to Burner Lines and at Steam to Burner Regulator due to Friction Etc.
Pressure in Oil Line at Burner in Lb. per Sq. In.

FIG. 1 STEAM AND OIL PRESSURES AT BURNER LINES

TRANSACTIONS, and the system used in these plants differs from that described in the paper merely in the use of a diaphragm pump governor to maintain a constant predetermined maximum pressure at the oil pumps; the oil-to-burner regulator then operates a throttle valve to give the desired pressure at the oil burners.

Under variable load the damper controller has been able to maintain CO_2 readings varying from 12 per cent to 14.5 per cent CO_2, for which the corresponding excess air for normal conditions is 28 per cent and 6 per cent, respectively.

After instructing the operators, and while the plant was still under the control of the engineers, an average economy was obtained for the month of September, 1915, as given in the following table:

Average number of turbine units in operation	1
Average daily load, 24-hour basis, kw	5980
Average steam pressure at boilers, lb. per sq. in.	178
Average vacuum in condensers, in. of mercury, absolute	2.66
Average rating on boilers, per cent	95
Gross boiler efficiency, per cent	80.9
Average economy, kw-hr. per bbl. of oil as fired	281
Average economy B.t.u. per kw-hr.	25900

In the subsequent operation of this plant by the owners the economy has been maintained practically equal to that shown under the direction of the engineers, but during the winter, due to colder circulating water, the economy is even better than indicated above. On the other hand, during the summer months, with the warmer circulating water and falling off in vacuum, the economy naturally drops to a lower figure than that given for the month of September.

This plant operates in conjunction with the hydroelectric plant at the Roosevelt Dam, and at periods of the year preference is given to hydroelectric power. As a result, there is a fractional load, or partial shutdown of the steam plant, and for certain months this in turn has naturally resulted in a reduced economy.

The operating results for the plant, furnished by Mr. W. W. Jourdin, Mem.Am.Soc.M.E., Chief Engineer of the Inspiration power plant, are given by the curves of Fig. 3. It will be noted that the best monthly economy for winter conditions has been 294.5 kw-hr. per bbl. of oil, or 20,910 B.t.u. per kw-hr.; and the poorest economy for summer conditions for the normal load has been 257.5 kw-hr. per bbl. of oil, or 23,700 B.t.u. per kw-hr., although for the month of September 1917, due to the very light load, the economy was only 237 kw-hr. per bbl. or 25,970 B.t.u. per kw-hr. As previously stated, this plant, in comparison with non-cooling-pond plants, is subject to an accumulation of scale in the condensers, and as a result there is a slight loss in vacuum. Since purified feedwater is used, the plant is not subject to troubles from scale formation in the oil-fired boilers, nor does any loss of fuel result from shutting down boilers for cleaning or boiler blow-off.

The curves of Fig. 3 give the operating records for combined boiler and economizer efficiency, atomizing steam deducted; this being the form in which the power-plant records are kept. A comparison of this result with the boiler efficiency tests would seem inconsistent without the explanation that the economizers at this plant heat the feedwater through a temperature range of from 40 deg. to 45 deg., whereas it will be noted that results for the Arizona Power Company's economizers, given in Table 2, indicate a temperature rise in the economizer of 91 deg. fahr. In proportioning the Inspiration economizers with reference to the investment and fuel saving, it was assumed that the average period of operation would be less than half the year, owing to the use of hydroelectric power; it was also assumed that the fixed charges would be very high. This combination of circumstances, together with high freight rates and construction costs in Arizona, resulted in the selection of an economizer of comparatively small surface, giving a favorable return on the investment but a result considerably less favorable than that attained in the average economizer with oil fuel, when measured only by temperature rise.

ECONOMY OF THE NEW CORNELIA COPPER COMPANY'S PLANT

Following the installation of the New Cornelia plant in November 1917, an attempt was made by the designing engineers to check the economy of the station, but owing to the war and a scarcity of labor this work had to be abandoned before completion. While it has never been possible to show the best performance of which the plant is capable, the operating crew have, for the most part, been very efficient in handling it, except during an illness of the chief engineer, when the economy of the plant fell off to a disappointing figure. This occurred during the summer and fall of 1918, and the figures for economy for that period are thus hardly fair to the plant. It should also be borne in mind, in connection with performance data, that the feedwater condition at this plant is such that the frequent shutdowns for boiler cleaning and the large amount of hot water blown off from the boilers affect appreciably its economy.

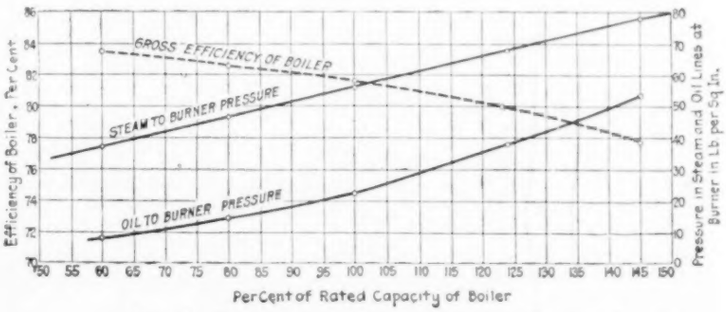

GROSS EFFICIENCY OF BOILER
STEAM TO BURNER PRESSURE
OIL TO BURNER PRESSURE
Efficiency of Boiler, Per Cent
Pressure in Steam and Oil Lines at Burner in Lb. per Sq. In.
Per Cent of Rated Capacity of Boiler

FIG. 2 PRESSURES AND EFFICIENCIES AT VARIOUS LOADS

This plant, due to its location in the southwestern portion of Arizona, is subject to more intense summer heat than probably any other power plant in the western territory, and this in turn gives rise to considerably less favorable cooling-pond and condenser performance, with respect to vacuum, for the summer months than for the winter months. The vacuum performance is also influenced by the accumulation of scale within the condensers between the periods of cleaning condensers, due to concentration of salts in the cooling pond.

The best economy for this station known to the writer is for the month of January 1918, the average performance for four successive days being about 324 kw-hr. per bbl. of oil, as shown in the following table:

Date 1918	Average load, kw.	Economy, kw-hr. per bbl. of oil	B.t.u. per kw-hr.
January 26	7921	321.7	18,975
January 27	7830	324.1	18,833
January 28	7725	324.2	18,829
January 29	7800	326.2	18,711

The poorest economy for this station, during the summer of 1917, was for the month of July, namely, 293.5 kw-hr. per bbl. The average vacuum was 1.66 in. absolute and the average load 5550 kw. The poorest economy during the summer of 1918 was also for the month of July, or 287.5 kw-hr. per bbl. The average vacuum was 2.14 in. absolute, the average load 5850 kw., and consequently the economy for the summer of 1918 was abnormally low.

The monthly report for December 1918 gives the following: Average load, 7800 kw.; average economy, 312 kw. per bbl. and 19,913 B.t.u. per kw-hr. The monthly report for January 1919 gives: average load, 7790 kw.; average economy, 317.9 kw. per bbl., and 19,535 B.t.u. per kw-hr. The improvement for the month of January over December is due to a straightening out of the aforementioned difficulties experienced in the summer of 1918, and it is the writer's belief that the station will soon be operating at its best previous economy for the corresponding season.

It will be noted that the economy of the New Cornelia plant is materially better than that of the Inspiration. This is due somewhat to the larger turbine units installed, but in the main to the higher steam pressure and to the improved design of cooling pond, which results in better vacuum. In comparing the economy of these cooling-pond stations with that obtained in tidewater plants, allowance should be made for the size of turbine units, the obtainable vacua under operating conditions, the increased head on circulating pump due to the greater quantity of water which must be handled through the condensers, and the increased pumping head due to the cooling-pond nozzles and longer lengths of circulating-water line.

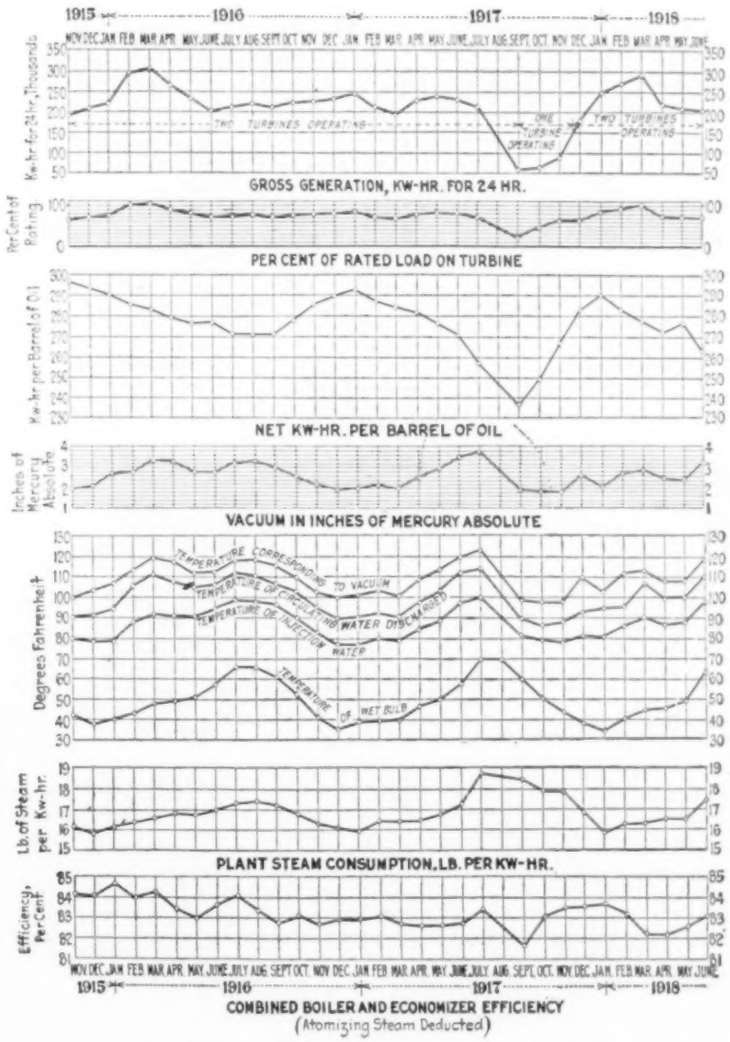
Economy of the Arizona Power Company's Plant

This plant was completed in September 1917, and due to the war conditions in the mining region it was difficult to assemble a skilled operating crew. The plant was furnished under a contract covering a complete plant-economy guarantee at 5000-kw. load, and the final test, covering 48 hours' operation in regular commercial service, under variable load, was concerned mostly with the economy at this load, although a run was made at 6000-kw. load, which is the rated capacity of the turbine. The results for the final test are given in Table 2. At all times during this test the plant was subject to a variable load, due to the regulation of the hydroelectric system. The oil was carefully weighed and the electrical output was measured by calibrated meters. The electrical output given is the net useful output for the station at the 2300-volt bus, deduction having been made for the power consumption of electric auxiliaries, including lighting for the operators' cottages, circulating water pump, deep-well pump and air washer. The average electrical auxiliary load was 46 kw., which is somewhat smaller than would have been the case had the entire head on the circulating water been overcome by pumping; against this condition is the fact that during the test the quantity of circulating water was somewhat less than specified, so that, roughly speaking, the one condition nearly offsets the other.

It is not possible to give daily operating results for this plant, at the load for which it was designed, for since its installation it has been maintained only for reserve purposes, carrying occasional peaks but the majority of the time a very light load, and for a number of hours during an average day with the turbine at standstill. Of course favorable economy is not possible under such conditions, as the fuel losses due to keeping hot boilers, piping, etc., the dead-load losses for the operation of auxiliaries, and the zero-load steam consumption of turbine result in a zero-load fuel consumption of the plant which is an appreciable percentage of the full-load fuel consumption. With the foregoing explanation, the results for February 1918 are as follows:

Total kw-hr.	1,235,580
Total bbl. of fuel oil used	4783.9
Total hours of operation	444
Average kw. for operating period	2800
Kw-hr. per bbl. of oil (delivered to lines, net)	258.5
Operating period load factor	0.467
Average kw. for monthly period	1838
Monthly period load factor	0.306

It is of interest to note that the turbine at the Arizona Power Company's plant is practically a duplicate of those at the Inspiration Copper Company's plant, having the same number of stages; the difference in the operating economy of the turbines being largely due to steam pressure. Here again is a marked


1915
1916
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1918
NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE
Kw-hr for 24 hr., Thousands
TWO TURBINES OPERATING
ONE TURBINE OPERATING
TWO TURBINES OPERATING
GROSS GENERATION, KW-HR. FOR 24 HR.
Per Cent of Rating
PER CENT OF RATED LOAD ON TURBINE
Kw-hr per Barrel of Oil
NET KW-HR. PER BARREL OF OIL
Inches of Mercury Absolute
VACUUM IN INCHES OF MERCURY ABSOLUTE
Degrees Fahrenheit
TEMPERATURE CORRESPONDING TO VACUUM
TEMPERATURE OF CIRCULATING WATER DISCHARGED
TEMPERATURE OF INJECTION WATER
TEMPERATURE OF WET BULB
Lb. of Steam per Kw-hr.
PLANT STEAM CONSUMPTION, LB. PER KW-HR.
Efficiency, Per Cent
COMBINED BOILER AND ECONOMIZER EFFICIENCY
(Atomizing Steam Deducted)

FIG. 3 OPERATING CHARACTERISTICS OF THE INSPIRATION POWER PLANT

TABLE 1 RESULTS OF EFFICIENCY TESTS ON STIRLING WATER-TUBE BOILER IN INSPIRATION CONSOLIDATED COPPER COMPANY'S PLANT

Class M No. 26 battery Stirling water-tube boiler with steel casing. Heating surface per boiler, 7129 sq. ft. Rated boiler hp., 712.9 (based on 10 sq. ft. per hp.). Boiler-room floor elevation, 3615 ft. Normal barometer, 26.13 in.

	Test at 100 per cent rating[1]	Test at 80 per cent rating[2]	Test at 60 per cent rating[2]	Test at 125 per cent rating
Date of test, 1915	May 29	June 1	June 2	June 4
Number of test boiler in plant	5	5	5	5
Duration of test, hours	10	6	6	10
Temp. feedwater entering boiler, deg. fahr	210.15	200.0	191.0	209.5
Temp. superheated steam, deg. fahr.	503.9	502.4	491.0	517.3
Deg. fahr. superheat	122.1	122.0	111.0	135.5
Temp. steam to burner, deg. fahr.	504.2	502.7	..	..
Temp. oil to burner, deg. fahr.	187.8	186.9	186.0	185.0
Temperature of flue gases, deg. fahr. measured across breeching outlet and in rotation — No. 1	466.5	423.7	389.0	495.0
No. 2	469.0	427.5	394.0	502.0
No. 3	470.1	434.7	389.0	507.5
No. 4	473.3	434.7	394.0	508.0
No. 5	472.5	432.5	391.0	507.5
No. 6	470.8	429.0	390.0	510.5
No. 7	471.3	427.0	392.0	506.0
Temp. outside air, deg. fahr.	95.0	90.2	86.5	69.0
Temp. air entering ashpit, deg. fahr.	93.1	100.3	95.0	75.9
Steam pressure, lb., gage	187.4	184.03	182.3	187.3
Pres. in oil line before burners, lb., gage	22.0	15.0	9. +	36.8
Pres. in steam line to burner, lb., gage — Before burner valves	56.6	46.8	38.0	67.0
After burner valves	..	..	..	..
Draft, in. water — Top of first pass No. 1	.014	+.016	.013	.005
Bottom of 2nd pass No. 2	.062	.080	.032	+.076
Front of damper No. 3	.076	.070	.020	+.091
Draft, inches of water (power-plant instrument), front of damper	.065	.074	.033	.110
Analysis of fuel oil by Smith, Emery & Co.:				
Water, per cent (by centrifuge)	.480	.490	.490	.490
Sand	Trace	Trace	Trace	Trace
Sulphur in per cent of dry oil	1.06	1.06	1.06	1.06
Carbon in per cent of dry oil	85.58	85.58	85.58	85.58
Hydrogen in per cent of dry oil	12.87	12.87	12.87	12.87
Net B.t.u. per lb. of oil as fired	18,540	18,540	18,540	18,540
Sulphur corrected in B.t.u. per lb. oil	85	85	85	85
Total water actually evaporated, lb.	232,736	104,394	76,857	269,963
Lb. water actually evaporated per hour	23,273.6	17,399	12,809	26,996.3
Factor of evaporation	1.124	1.134	1.137	1.131
Total water evaporated from and at 212 deg. fahr., lb.	261,594	118,383	87,386	305,328
Lb. water evaporated from and at 212 deg. fahr. per hr.	26,159	19,730.5	14,564	30,532.8
Total oil fired, lb.	16,743	7,498.5	5,458.5	19,907
Oil fired per hour, lb.	1,674.3	1,249.7	909.5	1,990.7
Boiler horsepower developed	758	572	422	885
Per cent of rated capacity, based on work done by water-heating surface	106.7	80.3	59.2	124
Lb. water actually evaporated per lb. oil	13.90	13.92	14.08	13.56
Lb. water evaporated per lb. of oil from and at 212 deg. fahr.	15.62	15.73	16.00	15.34
Efficiency of boiler based on gross evaporation per cent	81.76	82.64	83.74	80.29
Per cent CO_2 in flue gas at top of first pass	15.5	15.17	15.1	15.1
Percentage analysis of gases at bottom of second pass — CO_2	15.6	15.41	15.0	14.4
O	0.8	1.11	1.4	1.94
CO	Trace	0	0	0
N	83.6	83.48	83.6	83.66
Percentage analysis of gases at front of damper — CO_2	14.5	..	14.5	14.3
O	2.3	..	2.1	2.11
CO	Trace	..	0	0
N	83.2	..	83.4	83.59
Per cent excess air over chemical requirements at front of damper	4.19	..	4.19	6.14

[1] Apparent discrepancies in the draft readings of power-plant instrument and thermometers are due to the different location of the nozzles and to slight leaks in flue-gas piping.

[2] On account of the waste-heat boilers and intermittent firing of the other boilers the load was very jerky. On this account the damper was fixed to a low point on the draft and the ashpit door was regulated furing the test.

TABLE 2 RESULTS OF TEST OF THE ARIZONA POWER COMPANY'S STEAM PLANT AT TAPCO, ARIZ.

Duration of test, hours	6
Boiler pressure, lb. per sq. in., gage	250
Steam pressure at turbine throttle, lb. per sq. in., gage	238.5
Avg. temp. of superheated steam at boilers, deg. fahr.	546
Temp. of superheated steam at turbine, deg. fahr.	516
Temp. of feedwater entering boilers, deg. fahr.	207
Temp. of water leaving feedwater heater, deg. fahr.	116
Temp. of circulating water from condenser, deg. fahr.	62.4
Temp. of circulating water to condenser, deg. fahr.	45.7
Room temperature, deg. fahr.	83.2
Barometer, inches of mercury	26.773
Vacuum in condenser, inches of mercury	25.783
Absolute vacuum, inches of mercury	0.990
Temp. of flue gases leaving economizer No. 3, deg. fahr.	276
Average load, kw. per hr.	5,815
Power factor by power-plant indicator	0.93
Electrical Output by Integrating Meters:	
Gross kw. generated	34,890
Gross kw-hr.	5,815
Auxiliary power, kw.	277
Net kw. output	34,613
Net kw-hr. output	5,769
Oil Measurements:	
Total oil weighed, lb.	34,516
Correction due to diff. in temp. at start and finish, lb.	46
Oil actually used, lb.	34,470
Average gravity of oil (analyzed by Smith, Emery & Co.), deg. B.	17.65
Weight of oil per bbl. of 42 gal.	332
Heat value of oil (analyzed by Smith, Emery & Co.), B.t.u. per lb.	18,703
Economy:	
Fuel used per gross kw-hr., lb.	0.988
Fuel used per net kw-hr., lb.	0.996
Kw-hr. per bbl. of oil, gross	336.0
Kw-hr. per bbl. of oil net	333.3
B.t.u. per kw-hr., gross	18,478
B.t.u. per kw-hr. net	18,628

increase in plant economy due to an increase in steam pressure, and also by reason of the colder river water at the Arizona Power Company's plant as compared with the cooling-pond water at the Inspiration plant and the consequent improvement in vacuum. All economy figures are based on oil as fired, without deduction or correction for moisture, sulphur, or silt.

The engineers have endeavored to instill in the minds of the operators of these plants and to show by example that high economies need not merely be looked for during the test period, but can be maintained during the operating period. The Inspiration plant is large enough to permit the employment of a boiler-room engineer, but, due to their smaller size, such an engineer is not maintained at the other two plants. This plant was designed on the assumption that the average load would be maintained for a period of six months only during the year, and that oil delivered would cost about $1.45 per bbl. The New Cornelia plant was designed on the assumption that oil would cost $1.25 per bbl., but since the date of design of these plants the cost of oil has materially increased.

PERSONNEL

The selection of the principal equipment for the Inspiration plant and its general layout were made jointly by John Langton, Consulting Engineer for the Inspiration Consolidated Copper Company, and Chas. C. Moore and Co. Engineers, which firm was also responsible for the detailed designs, installation and tuning up of the plant.

For the New Cornelia plant the entire work was in the hands of Chas. C. Moore and Co. with the approval of a A. G. McGregor, Consulting Engineer for the New Cornelia Co.

The Arizona Power Company's plant was designed and built by Chas. C. Moore and Co. Engineers, with the approval of R. S. Mason, Chief Engineer for the Arizona Power Co.

A considerable portion of the testing work on the Inspiration plant was handled by A. G. Budge, under the writer's direction, and for the New Cornelia and Arizona Power Company plants by T. B. Paulson, also under the writer's direction.

Air Fans for Driving Generators on Airplanes

By CAPT. G. FRANCIS GRAY[1], U. S. A.; LT. JOHN W. REED,[1] U. S. A.; and P. N. ELDERKIN[1]

In this paper the authors first briefly describe the method employed by the Radio Development Section of the War Department in testing air fans used for driving the electric generators usually installed on airplanes for radio communication. They next discuss at some length the various types of air fans used during the war and present numerous photographs and curves clearly illustrating the construction of the fans and their operating characteristics.

The difficulty of the problem lay in designing a fan which would turn at constant speed in the air streams of widely varying speed set up by the airplane in flight. The various types of fans tested were: Fixed-blade fans of special blade shape; fixed-blade fans with wind brakes centrifugally regulated; fixed-blade fans using a friction clutch or a friction brake centrifugally regulated, and pivoted-blade fans in which the pitch is centrifugally regulated.

DURING the war extensive use was made of radio telegraph and telephone apparatus on military airplanes, and the problem of power supply for such equipment received a great deal of attention. The possible sources of energy may be listed as follows:

a Storage batteries or dry batteries
b Generators driven from the airplane engine, with or without floating storage batteries, and supplying the radio sets directly or through dynamotors
c Generators driven by separate gasoline engines
d Generators driven by air fans, or "windmills" placed in the air stream outside the airplane fuselage.

From an economical point of view, method *b* is preferable. It was seriously considered, but since it involved coöperation between organizations normally operating independently, its adoption was delayed. Meanwhile the practice in our Army followed that of our Allies, principally the French, in the use of method *d*, mounting the generator outside the airplane fuselage and driving it with an air fan.

The work done on the development of air fans for this service was carried out by the Radio Development Section of the Signal Corps, and since it was done under the press of military necessity it was directed entirely by utilitarian considerations, was often fragmentary, and neglected investigations, the need of which was realized, but for which time and personnel were not available. This record is presented with the work still in unfinished form in the hope that results obtained may be useful to those who may have occasion to carry out further investigations on the problem.

Conditions for Which the Air Fans Were Designed

Two sizes of generators were to be driven by the air fans it was desired to develop. The essential data on these are as follows:

	Generator for Radio Telegraph Sets	Generator for Radio Telephone Sets
Generator diameter, in.	6¼	4¼
Generator output, watts	200	80
Required power from fan, watts	330	250
Normal speed, r.p.m.	4500	4000

[1] Engineering and Research Division, Radio Development Section, War Department, Washington, D. C.

For presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, of The American Society of Mechanical Engineers. The paper is here printed in abstract form and copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

Methods of Test

Practically all of the tests recorded in this paper were made with the wind tunnel of the Bureau of Standards, and the management and personnel of the Bureau aided materially in expediting them. A special testing generator was mounted in the wind tunnel and the fan to be tested was attached to it. This generator was provided with a magnetic tachometer, a separately excited field, and convenient means for applying load to the armature circuit. The external shape and size of the machine were made identical with those of the radio generators, with which the air fans were to operate in service, and with this generator and the regular wind-tunnel equipment for measuring wind velocity, tests could be made rapidly and accurately.

All of the air fans considered in this development have normal speeds of 4000 r.p.m., or above, and the centrifugal forces are very considerable. It was therefore found necessary to provide an overspeed test to precede the wind tunnel test. For this purpose a 30-hp. motor operating through a 43-to-3 De Laval speed-increasing gear to a suitable shaft extension for the fan was set up. This device was capable of driving the air fans at speeds up to 14,000 r.p.m. and to prevent damage to gears or bearings in case of failure of the fan, a "weakest point" was provided by a replaceable notched-shaft extension. Failure at this point merely resulted in the breaking of the replaceable shaft extension, and of course the destruction of the fan, without injury to bearings or gears. Heavy guards prevented the flying fragments from causing any damage. This equipment was designed by Capt. F. E. Pernot, Officer in Charge of the Signal Corps Laboratories at the Bureau of Standards.

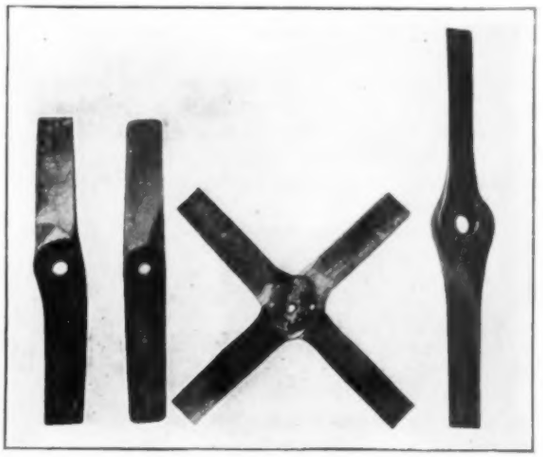

Fig. 1 Pre-War Air Fans

There is one serious objection, however, to this method of overspeed testing in that it absorbs a large amount of power and puts abnormal thrust strains on the fans. A baffle to prevent air flow materially reduced this effect, and later experience indicated that it would have been preferable to make the overspeed test in a very simple auxiliary wind tunnel with an aperture just large enough to drive the unloaded fans at the speed desired. Nevertheless the apparatus just described was used in all tests discussed in this paper.

In cases where the strength of a fan was problematical, it was first given an overspeed test only slightly in excess of the running speed expected in the wind tunnel. After the wind-tunnel test it was again tested to the required overspeed or to destruction. The best fans were required to withstand up to practically double normal speed.

Simple Non-Regulating Air Fans

As in all power-plant problems, the ideal in this development was a constant-speed drive for the radio generator. When the development began, the only air fans available were non-regulating wooden fans such as those illustrated in Fig. 1. These fans have the characteristic that rotational speed is practically proportional to air speed, and when combined with the normal variations in the speed of the airplanes this fact leads to very severe requirements for the generator. As an example, a generator which would give satisfactory performance at 3750 r.p.m. was required to withstand an overspeed test of 14,000 r.p.m. for mechanical performance and, with the addition of a very special regulating device, to hold its voltage within 15 per cent at speeds from 4000 to 12,000 r.p.m.

Although the need for better air fans was obvious, the non-regulating types had to be used until others could be developed, and a considerable amount of work was done in adapting them to the particular requirements to be met. Fig. 2 shows the construction of one of the final forms used with generators for radio-telephone sets, and Fig. 3 its performance in the wind tunnel. Figs. 4 and 5 give similar information on a larger-size fixed-blade fan used for radio-telegraph sets. Fig. 5 also gives an idea of the variation in individual fans supposed to be identical. Considerable trouble was experienced with these fans due to the fact that the method for calculating air fans was assumed to be the same as that used for propellers.

Obviously it is desirable to establish the correct method of calculating these fans, but the pressure of more important work prevented its being undertaken by the Radio Development Section. The subject, however, was given much attention by Mr. E. N. Fales, of the Airplane Engineering Department, Bureau of Aircraft Production of the Army, who assisted the Section very

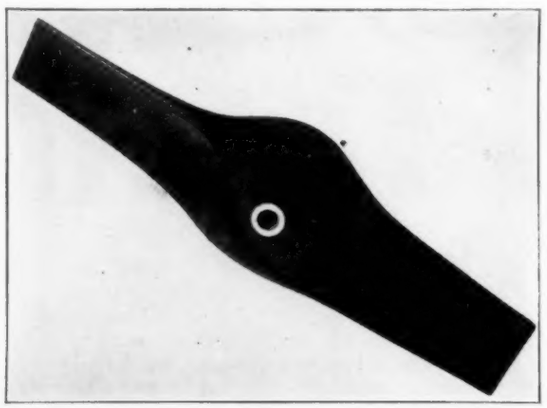

Fig. 2 Type FA-3, Non-Regulating Air Fan, for Radio-Telephone Generators

materially during the early stages of the development described in this paper, and it is hoped he will publish his conclusions.

Regulating Air Fans

No one can work with simple air fans without being impressed with the desirability and apparent simplicity of modifying them so that instead of the straight-line relation between air speed and speed of rotation there will be more or less tendency toward constant rotational speed with varying air speed. Among the disadvantages which may be corrected by making the air fans self-regulating are the following:

a Undue head resistance
b Excessive centrifugal stress in armature windings
c Vibration
d Commutator and bearing troubles
e Troubles with voltage regulators
f Troubles in radio sets due to varying voltage.

During the progress of this development a great many schemes for the construction of self-regulating fans were proposed. As all previous experiences led to the conclusion that the performance of a fan could not be predicted with any degree of accuracy, every reasonable suggestion was carefully considered and if possible tried out. Fundamentally all the fans tested may be classified under five principles of operations as follows:

a Fixed-blade fans of special blade shape
b Fixed-blade fans with wind brakes centrifugally regulated
c Fixed-blade fans using a friction clutch centrifugally regulated
d Fixed-blade fans using a friction brake centrifugally regulated
e Pivoted-blade fans in which the pitch is centrifugally regulated.

Fixed-Blade Fans of Special Shapes. Certain air fans submitted to the Signal Corps were supposed to give speed regulation on the principle that the angle of attack and efficiency can be made to alter with the wind velocity in such a way that the ratio of wind velocity to r.p.m. need not be constant. Tests were made first on a series of blade sections and later on a fan, shown

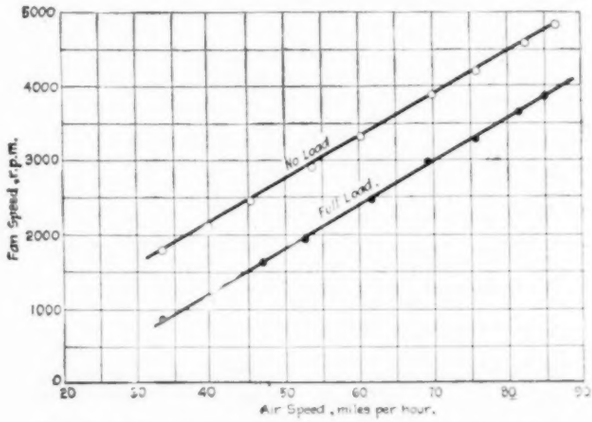

Fig. 3 Performance Curves of Type FA-3 Air Fan
(Diam., 15 in.; pitch, 2.1 ft.)

at the right in Fig. 1, which was said to possess the regulating features in a marked degree. The conclusion from these tests was that at no load the performance of properly designed fans tends to confirm the hopes of the designers though the magnitude of the regulating effect is small; but under load, particularly varying load, it was impossible to distinguish any improvement over the ordinary fixed-blade types of fans. Consequently this method was discarded as of no practical value.

Fig. 4 Type FA-6, Non-Regulating Air Fan, for Radio-Telegraph Generators

Fixed-Blade Fans with Wind Brakes. Fans of this type are provided with wings, pins or other projections which are normally enclosed in a recess in the blade, but which are caused by centrifugal force to emerge and so retard the rotation of the fan. They have the disadvantage of low efficiency and consequent high head resistance, but were considered worth trying. Fig. 6 shows various development models. Round rods, rods with cloth and metal wings, flat strips, etc., were tried for the moving brake element. Many showed practically no regulation of course, but others were reasonably promising. Among such was the type in which the brake arms were pivoted and moved out into the

air by the action of centrifugal weights. Another interesting fan had the break arms actuated not by centrifugal force but by the air pressure on a plate mounted in advance of the nose of the fan, and gave a curve in which, for a certain range, the r.p.m. actually decreased with increase in air velocity.

The net conclusion from this research was that the wind-brake principle would give fairly good characteristics over a limited range of air speed, and with further refinement it might have been worth putting into production. However, that stage was never reached due to the work on the pivoted-blade type of fan described below.

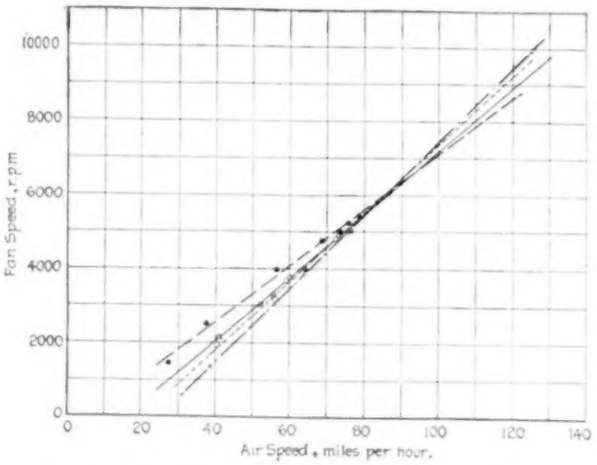

FIG. 5 PERFORMANCE CURVES OF TYPE FA-G AIR FAN
(Diam., 20 in.; pitch, 1.75 ft.)

Friction-Clutch and Friction-Brake Fans. As in the types of regulating air fans discussed above, the friction-clutch and friction-brake principles of operation are inherently objectionable on account of their low efficiency and consequent high head resistance. They offered a possible solution, however, and were tried out experimentally. In the friction-clutch type of fan the fan hub is capable of free rotation about the shaft of the generator, which it drives through a friction clutch. The clutch is released by the action of centrifugal weights when the speed passes the predetermined maximum, permitting the fan to run at higher speed than the driven shaft of the generator. The curve of this fan

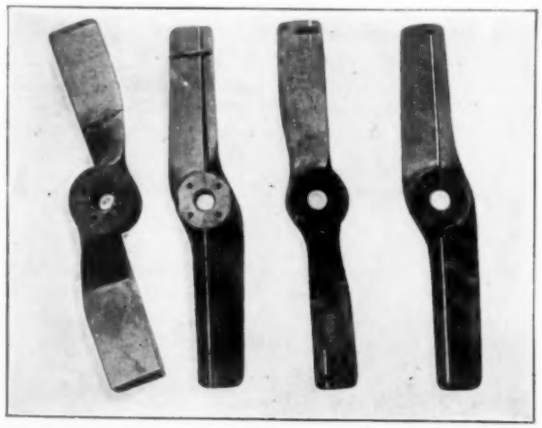

FIG. 6 FIXED-BLADE FANS WITH WIND BRAKES

was satisfactory for the first model, but the heating due to slipping of the clutch at high velocities was too great to permit the use of the fan in practice and the development was abandoned.

In the friction-brake type of fan the fan is keyed to the generator shaft and is prevented from exceeding normal speed by a brakeshoe operated by a centrifugal weight and bearing on a plate attached to the generator frame. This also was tried, and gave results essentially similar to those obtained with the clutch type. With the very considerable variation in air speed met with on airplanes, the friction devices generated so much heat that their use was impossible.

Variable-Pitch Air Fans. The ideal principle for the design of a regulating air fan is that of varying the pitch of the blades to correspond to the variation in air speed; this principle is by no means new, having been considered in a variety of forms for propellers for a number of years. The great difficulty in actual construction has been that the mechanical strength necessary to withstand the very high centrifugal forces and the delicacy of operation necessary for close regulation are very hard to combine.

This objection does not apply so forcibly to fans using very thin blades which are expected to warp under centrifugal action to change the pitch and a few samples which it was hoped would operate on this principle were tested. They were unsuccessful principally on account of mechanical construction and improved samples were never made up. The method is in any case of doubtful utility since it can probably take care of only limited variations in speed, whereas the pivoted blade fans are capable of regulating over the widest variations in air speed likely to be met with in airplane practice.

Pivoted-Blade Air Fans. The earliest pivoted-blade fan to come to the attention of the Radio Development Section was made by the Sperry Gyroscope Company, but it proved unsuccessful, due to mechanical weakness. It was, however, the forerunner of very successful fans, and serves to illustrate the general principle on which all operate. The blades are mounted on bearings and are capable of rotating through a considerable angle. Centrifugal weights are mounted on arms attached to these blades and tend to turn them in the proper direction to increase the pitch. A resisting spring and necessary hub complete the mechanism.

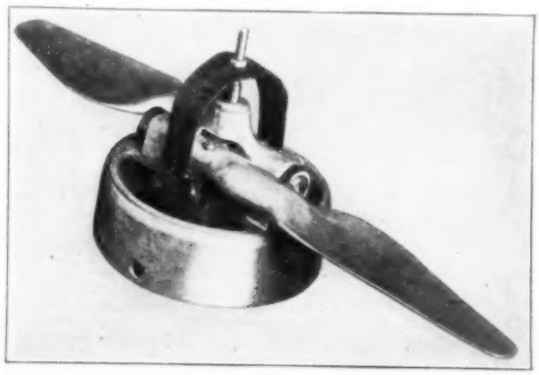

FIG. 7 TYPE FA-4-A, VARIABLE-PITCH AIR FAN

The first model to perform satisfactorily was designed by Mr. Thomas Slate, of the American Mechanical Improvement Company, of Washington, D. C. The very great improvement over the fixed-blade fans then in use made the production of this fan highly desirable, and it was undertaken at once under purchase specifications as follows:

Operating air-speed limits	45 to 300 m.p.h.
Normal speed	4500 r.p.m.
Speed variation less than	Plus or minus 4 per cent
Overspeed test	8000 r.p.m.

It was, of course, realized that this fan was by no means in its final form, and work toward improving it and providing new sources of production was carried on as rapidly as possible. One of the objections to the original design was that the particular mechanism used caused the centrifugal force to increase as the sine of twice the angle, while the spring restraining force increased according to a straight-line relation. In the second successful design this was corrected by the use of a special linkage between spring and blade which modified the curve of spring resistance to fit that of the centrifugal weight. Fig. 7 shows one of these fans and Fig. 8 its performance. In this as in many other cases of radio develop-

ment work, the design was conceived and outlined by the Signal Corps engineers and the details worked out at once by the manufacturer (in this case the American Propeller and Manufacturing Company) in a form ready for immediate production.

The third successful design of variable-pitch air fan was the work of Mr. Pinaud, of the Des Lauriers Aircraft Corporation, and differs very radically from those previously described. It uses

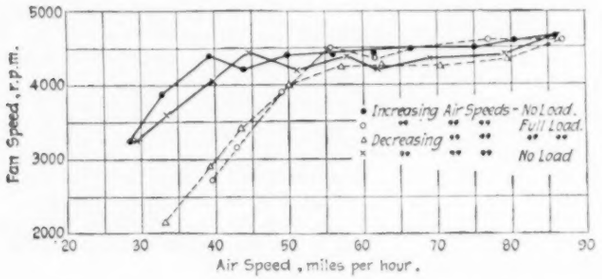

FIG. 8 PERFORMANCE CURVES OF TYPE FA-4-A AIR FAN
(Diam., 20 in.; pitch variable)

only one blade, and its principal advantage is that by ingenious counterbalancing practically all strain is taken off the bearings whereas in other forms the thrust bearings must carry a very considerable load—both radial and thrust—due to the high speed of rotation, and the unbalanced designs of the blades. Friction, of

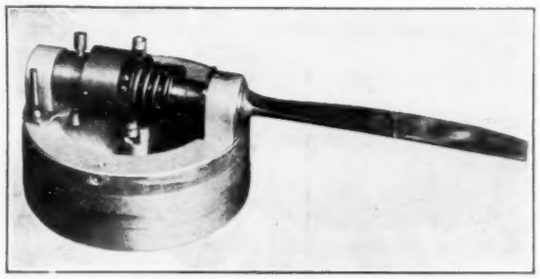

FIG. 9 TYPE FA-8, VARIABLE-PITCH AIR FAN, SINGLE-BLADE, 200-WATT

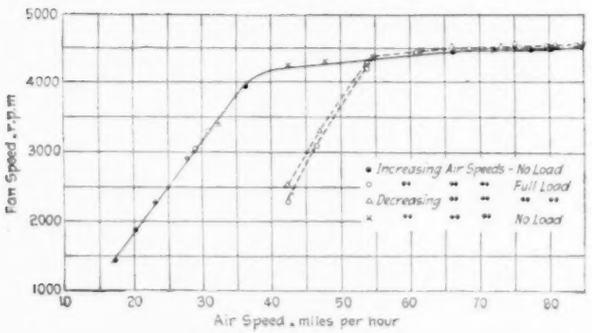

FIG. 10 PERFORMANCE CURVES OF TYPE FA-8 AIR FAN
(Swept diam., 20 in.; pitch variable)

course, results in considerable "lag" in the performance of the fan. The mechanical construction of the Pinaud fan is also a considerable improvement over its predecessors in simplicity and ease of manufacture. Figs. 9 and 10 show its construction and performance.

HEAD-RESISTANCE TESTS

A demonstration of the value of the regulating air fans in reducing head resistance was made by the direct test of a complete radio-telegraph transmitting set in the wind tunnel. A run was first made with the set equipped with a fan hub and nose cap but no blades; then a second run was made with a fan operating normally with the generator both loaded and running light, and finally a third run was made with the fan blades locked at several values of pitch. The results of these tests are shown in Fig. 11, from which the following conclusions may be drawn:

The head resistance of the set fully loaded in an air stream of 75 miles per hour is 6.5 lb. At this air speed the resistance of the blades alone equals the resistance of the body, after which the resistance of the blades remain nearly constant, while that of the body increases as the square of the air speed. The body alone has 5 lb. head resistance at an air speed of 90 miles per hour, and at the usual ratio of ⅛ hp. from the engine per lb. of head resistance, this requires 0.36 hp. from the engine. On a basis of 20 lb. in the fuselage per hp. from the engine, the set would weigh 13 lb. more than it now does and still be no more load on the

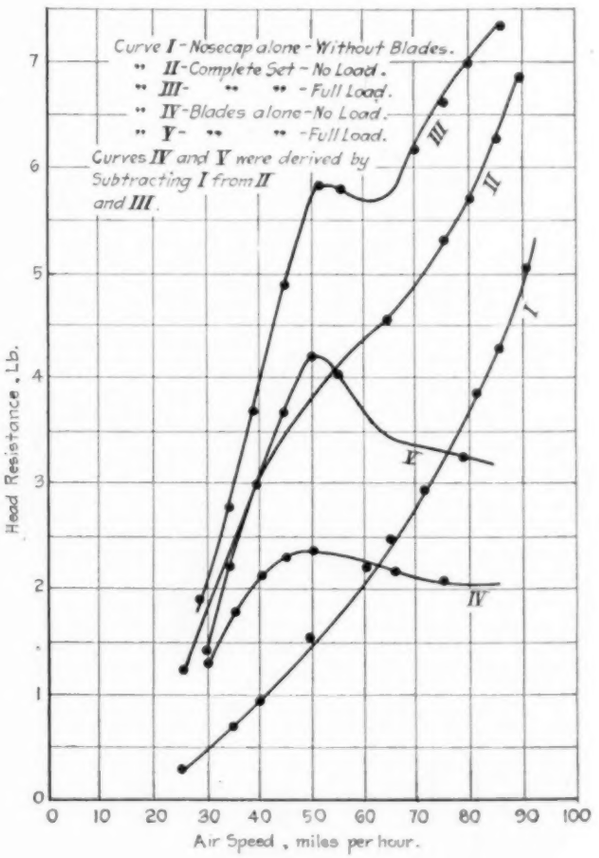

FIG. 11 HEAD-RESISTANCE CURVES, TYPE FA-4 AIR FAN

engine provided it was mounted in the fuselage and obtained its power directly from the engine. This emphasizes the desirability already mentioned of obtaining all electric power by direct drive from the engine rather than from air fans where it is possible to do so.

AIRFOIL TESTS ON BLADES FOR REGULATING AIR FANS

In designing blades for regulating air fans, the effect of wind pressure in producing torque around the blade axis has been questioned, and obviously such an effect might seriously interfere with the performance of the fan. To obtain data on this point tests were made on blades from a fan of the type shown in Fig. 7, using an airfoil balance.

The results thus obtained show that this effect is negligible so far as practical designing is concerned.

CORRESPONDENCE

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Threads and Thread Gages[1]

TO THE EDITOR:

The war brought with it many new problems, among which were the building up quickly from raw labor of a force capable of attaining and maintaining a high standard of work upon an emergency production basis, and the organization and education of a competent force to inspect the work done.

A cause of misunderstanding has been the fact that the inspection force, not being well grounded in the fundamentals of manufacture, have thought the manufacturer lax in his methods or deficient in knowledge, and the manufacturer on the other hand has taken it for granted that the inspector was familiar with manufacturing methods and has not taken pains to explain manufacturing difficulties.

The greatest of our troubles in this respect has probably been the question of threads and thread gages. Threads at best are a debatable and theoretical subject of which more is guessed at than known, and of which figures do not tell all that should be said. At the beginning of the war the Bureau of Standards was asked to devise means of checking gages, and with its usual thoroughness at once developed excellent means of measurement; but unfortunately no gages that were manufactured could pass their tests.

This, however, was remedied in time, but our ability to measure still outstripped our ability to make gages and much time and money was wasted. Eventually such progress was made in thread-gage manufacture that today almost perfect gages are turned out; but to what end? Threads have not improved nor the method of making them, and again in our gages we have far outstripped our ability to make threads. There seems to be no reason for making the production of threads more costly than at present, since they are satisfactory as regards strength; and whether they are or are not satisfactory otherwise the gage does not definitely tell us.

In no other place that I can at present recall is the gaging of a piece made more severe than the service required by the use to which it is to be put. For instance, if we are to measure the outside diameter of a cylindrical body, we do not use a cylindrical gage the height of the piece and set the piece in it; we use a snap gage or a ring gage. In the case of a thread, however, we make our gages at least one diameter thick—in some cases more—and while we use a wrench for ultimately screwing down a bolt and usually throw it out if it goes in by hand, we expect every bolt to go in the thread gage by hand and without force and make no allowance in our gages for final screwing down, thus defeating the very object we are striving for, to wit: a good fitting male and female thread. I do not think it an exaggeration to say that if we took a bolt and nut that fitted perfectly in the gages, we would reject both when we used them. The inaccuracies or burrs are what make the apparent good fit.

Further, we do not cut the same thread upon different kinds of material with the same die. In manufacturing we have to deal with open-hearth and bessemer steel, brass and copper, which neither tap nor thread the same. Should we not then make our gages different for each material? The number of good threads in a given lot of pieces made with the same die or tap is dependent first upon the nature of the material used; second, the tolerance allowed; third, the method of relieving threading tools; fourth, the relation of the weight of the die and the nature of the piece it is cutting; fifth, the mechanical means used to cut; sixth, the nature of lubricant used and uniformity is thus a matter of percentage.

In a mechanical sense the only part of the thread that is vital is at or near the pitch line. Still, we have insisted upon 100 per cent height of thread because the draftsman so pictured it and it has been necessary to make taps and dies to cut as the gage demanded, rather than to make them as they should be.

Another fact to be considered is that in most other things we usually gage only finished parts. We never think of holding to close limits on a roughing cut, but still we insist upon doing so on a thread which is precisely a rough cut as it is made in a single cut with a tool which fundamentally lacks necessary clearance, rake, and rigidity.

Another point which shows the weakness of our thread-gaging methods is that many threads enter the maximum gage with difficulty the first time and shake the second time. The answer to this, of course, is that the threads are rough at first and fit the gage snugly. In the process of trying them in the gage, however, they become smooth and where gaged a second time are a loose fit. This is more particularly true of brass. Also, using a ring gage often takes off the point of the thread so that it will not pass the maximum-diameter test. I know of a firm that lost thousands of brass pieces with a fine thread by their being pressed into a ring gage, and it took very little cocking or pressure to do it.

While we must maintain standards, we do not need watchmaking on locomotives. Traction engines are built differently from automobiles and while both use practically the same parts, the gaging that may be vital on an automobile is a non-essential on traction engines.

In practice it is usually the difference in the lead between the male and female thread that makes the fit. We make our gages accurately in this respect and then find it is impossible to procure taps and dies anywhere near as accurate.

The question of lead and angle has never been considered so important as since we entered the war. I think it may be stated without exaggerating that there are not a hundred lathes in the United States having lead screws of identically the same characteristics, considering as a basis the degree of accuracy used by the Bureau of Standards in measuring gages. This being so, it follows that it is impossible to get taps from different makers, or even from the same maker, which will check up accurately with a gage made by some one else, and a lead adjuster does not entirely cure this fault.

With the introduction of the wire method of measuring, it is now necessary in cutting a thread to figure out in abstruse mathematics the angle the thread tool should have in order to generate a thread of the required angle and pitch diameter.

The question naturally arises, then, Are we not making our threads to conform to the results secured by wire measurements, and misleading ourselves as to the angle and pitch diameter obtained? Are we not taking the wire system as an end and making our threads conform to the wire rather than using the wire as a means of measurement? In other words, we do not know whether we are getting the correct angle and pitch diameter with our wires, but we make our threads conform to them, nevertheless, and i believe that the wire system of measurement should be used for duplication only and not to set standards.

When the cross-section of the thread of a gage is projected on a screen the surface is shown to be full of hills and valleys even when ground—quite often the tooth is rounded. The object of the projectoscope is to indicate whether or not the tops of these hills constitute the desired angle. It is obvious that in using

[1] Contributed as a discussion of the subject of Threads and Thread Gages presented at the Annual Meeting, December, 1918.

wires one may rest in a valley and the other on top of a hill—which shows the fallacy of attempting to say that a thread is 0.0002 in. or 0.0003 in. undersize or oversize on the pitch diameter. We do not know that we are measuring on the pitch diameter, which is simply a mathematical point of departure where two theoretical circles touch.

It may be asked why a thread is not as readily measured on the pitch diameter by the wire method as is a gear, where the method originated. The answer is that on a gear the wire has a long bearing on a finished, smooth surface with the tool marks parallel with the wire and much finer in proportion, giving it a true seat. It would not be attempted to measure helical or bevel gears by this method. It is obvious that the only way to do this would be with a ball and not a wire. This same is true of helical threads.

Many thread gages have been rejected because they were 0.0002 in. off on the pitch line, and when this occurs it begins to tax our credulity as to the ability of man to make these measurements, since we know that on a straight, flat piece two men can seldom measure within 0.0002 in., even with the same micrometer, the difference being due to the difference in pressure and feel. Of course here again we must not confuse the facilities of the Bureau of Standards with those available to the tool manufacturer doing war work.

When we consider that 0.0001 in. on the wire used for measuring a 32-pitch thread makes a difference in angle of 0.5 deg., we can see to what impossible refinement we are carrying things when gages were rejected that showed an error of more than 10 min.

The question of the maximum diameter is always a subject of discussion and dispute. Most drawings call for a theoretical 100 per cent thread or leave it to be inferred. In practice in the past we have been able to secure 75 to 85 on bessemer rod; from 85 to 90 with open-hearth rod and 90 to 95 on good brass. With the thread miller it is possible to get 75 to 85 per cent of pieces with 100 per cent thread, but fine threads usually require burring; and it is also in some cases possible to get a 100 per cent thread by cutting a slot in the bottom of the thread on the tap, thus allowing the metal to flow.

Having hypothetically gone to the practice of milling our threads and having secured thereby what by individual measurements we call a 100 per cent thread of the proper lead and pitch diameter; and having also secured from the Bureau of Standards a gage as near perfect as they can manufacture, what will the gage tell us with regard to the thread? It does not tell us whether the thread angle is too small nor whether the pitch is correct. It does not tell whether the outside diameter is too small. It simply tells us three things: (1) whether the outside diameter is too great, (2) whether the bottom of the thread is oversize, and (3) whether the lead is correct.

I am assuming that the above was a maximum gage. Adding a minimum gage would establish only one thing more; i.e., the minimum outside diameter.

I have stated that if we had perfect gages and a perfect nut and bolt, we would reject them when we came to use them. So, logically, if perfection is not satisfactory, less than perfection must be. We may lay it down as an axiom that two threaded pieces, the angles of the threads of which are the complement of each other, cannot, if made correctly, produce a tight fit. What is required is to place enough metal on the male member to fill the female threads, and by this process any desired fit may be secured, regardless of tolerance.

C. B. LORD,
Gen. Supt. Wagner Elec. Mfg. Co.

St. Louis, Mo.

Laying a 6-ft. Water Pipe Across Passaic River

TO THE EDITOR:

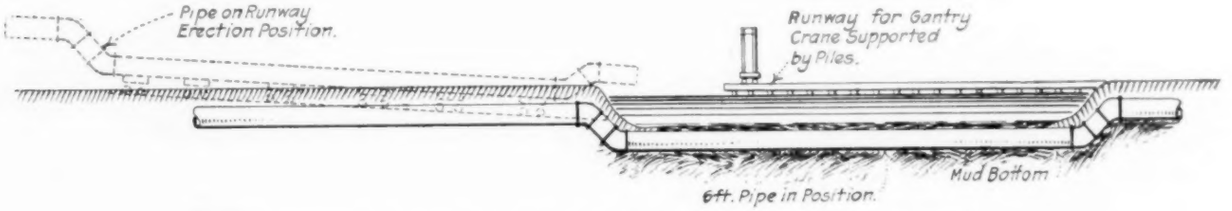
An interesting problem in mechanical and civil engineering may be observed at Delawanna, N. J. (nine miles from Hoboken via D., L. & W. R.R.), where the Jersey City Water Department is laying a new 6-ft. diameter water-supply pipe across the Passaic River.

The pipe, which is built of $\frac{5}{8}$ in. steel plate, is to be riveted together and tested hydraulically before being placed in position.

On the west side of the river and sloping gradually toward it, a narrow-gage track has been laid. About two-thirds the distance across the river, which at this point is about 200 ft. wide, two parallel rows of piles to support a gantry crane have been driven. The gantry could not be carried all the way across the river because navigation had to be kept open.

The plan of operation is to build the pipe on the wheeled carriages placed on the narrow-gage track, and then gradually to move it into the river, supporting it partly by the crane, by the traveling carriages, and by floating.

When the correct position has been reached the pipe will be sunk to its proper level, set and connections made to the existing pipe on each bank of the river. The pipe to be handled is about 250 ft. in length and weighs in the neighborhood of 65 tons.



METHOD EMPLOYED IN LAYING A 6-FT. WATER-SUPPLY PIPE ACROSS THE PASSAIC RIVER

ROBT. LACY.

Washington, D. C.

Lubrication of Air Compressors

TO THE EDITOR:

The report of Mr. H. V. Conrad, page 384 of the April issue of MECHANICAL ENGINEERING, concerning the lubrication of air compressors is excellent, and should be given serious consideration by the owners and operators of such machinery.

If I may add a suggestion in this connection, I would strongly advocate the use of a suitable oil separator to be placed on the discharge line between the air cylinder and air receiver, and so arranged as to permit the blowing out of the entrapped oil at regular intervals, say once each day.

An oil separator such as is used on the gas-discharge lines of ammonia compressors would meet the requirements.

By following this plan most of the oil passing from the air-compressor cylinders will be entrapped and prevented from getting over to the air receiver, and this oil when drawn off can usually be used to advantage somewhere about the plant if properly filtered.

Another thing in this connection: It would help matters to place on the drain of the air receiver a suitable trap to automatically drain it of moisture and oil. This trap would, of course, be similar to the ordinary steam trap, except that its valves should be designed for the character of the work they are to perform. It should be by-passed, permitting hand draining of the receiver in case trap repairs are to be made.

C. T. BAKER.

Atlanta, Ga.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation in the form of a reply is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, The Journal of the Society, in order that any one interested may readily secure the latest information concerning the interpretations.

Below are given the interpretations of the Committee in Cases Nos. 228-235, inclusive, as formulated at the meeting of April 25, 1919, and approved by the Council. In this report, as previously, the names of the inquiries have been omitted.

CORRECTION

Case No. 223: Through an oversight certain typographical corrections in Case No. 223 which were ordered by the Boiler Code Committee were overlooked in their publication in MECHANICAL ENGINEERING. The reply in this Case should read as follows:

Reply: Under the requirements of Par. 239, the furnace will not require staying. There remains, therefore, only the crown sheet, top head of the boiler and the flue to be considered. Par. 203*d* or the latter part of Par. 216 are applicable to the crown sheet and top head, if formed from flat sheets. If, on the other hand, the crown sheet and top head are dished, the maximum allowable working pressure is calculated from Par. 195. Par. 241 applies to the flue.

CASE NO. 228
(In the hands of the Committee)

CASE NO. 229

Inquiry: Is it not permissible under the requirements of the revised edition of the Boiler Code (Edition of 1918) to equip a boiler with safety valves set for the pressure for which the boiler is designed, even though the boiler is to be operated at a pressure lower than this maximum allowable working pressure? It frequently occurs that a boiler will be built for a certain pressure, but will be operated initially at a lower pressure and the pressure increased later, and it would obviously be of great convenience to boiler manufacturers if the safety valve could under such conditions be set for the maximum allowable working pressure.

Reply: There is no way by which the exact safety valve capacity can be determined without knowing the pressure under which the boiler is to operate. Pars. 270, 271 and 274 give the rules for determining the capacity under the construction and after the operating pressure is known.

CASE NO. 230
(In the hands of the Committee)

CASE NO. 231

Inquiry: Is it necessary under the requirements of the Heating Boiler Section of the Code, to construct boilers which exceed 60 in. in diameter but are to be operated at pressures not exceeding 15 lb., according to the requirements for power boilers?

Reply: Part I, Section II of the Boiler Code, does not specify that heating boilers exceeding 60 in. in diameter, need to be built in accordance with power boiler rules. The only special requirement of steam heating boilers over 60 in. in diameter carrying not to exceed 15 lb. per sq. in., is that under Par. 341, the longitudinal joint shall not be of lap-seam construction.

CASE NO. 232

Inquiry: Is it necessary that the bolting face of a pressed steel flange as shown in Fig. 1 riveted to a boiler shell for use

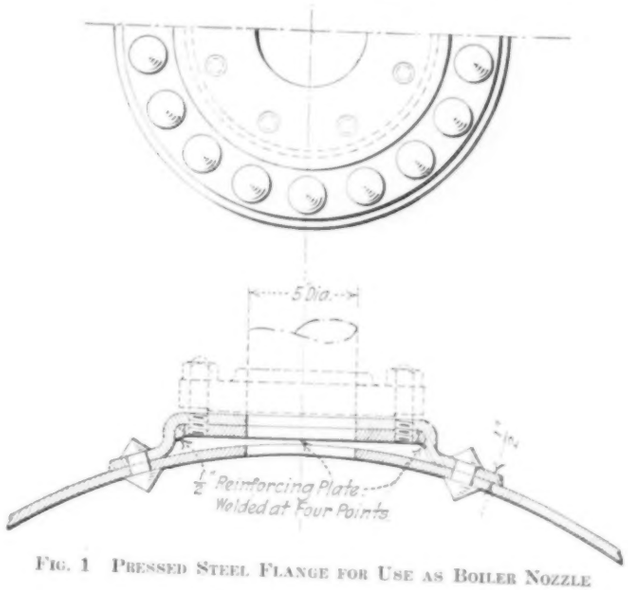


FIG. 1 PRESSED STEEL FLANGE FOR USE AS BOILER NOZZLE

as a nozzle, must comply with the requirements for flanges given in Tables 16 and 17? Should the thickness of such a steel flange conform to that required in these tables for cast iron?

Reply: It is the opinion of the Committee that any form of construction of flange within the stress limits used in boilers specified in the Code may be used for a flange which is attached to the boiler. The diameter of bolt circle and requirements as to number and size of bolts, should conform to the requirements of Tables 16 and 17.

CASE NO. 233

Inquiry: Do the requirements of Par. 258 of the Boiler Code, respecting the reinforcement of handhole openings, apply in general or only to handholes placed in boiler shells?

Reply: The requirements of Par. 258 are intended to apply to handholes placed in the cylindrical sheets of shells or drums.

CASE NO. 234

Inquiry: Is it necessary that washers used between the curved surface of the dished head of the drum of a water tube boiler and the nuts of threaded stays, be of cast steel, or may they be of cast or malleable iron? These washers which are of special wedge shape, are not exposed to any high heat, but are merely used in compression.

Reply: It is the opinion of the Committee that the washers shall be made of wrought or cast steel, or wrought iron.

CASE NO. 235

Inquiry: Is it permissible under the Rules of the Boiler Code to form an outlet nozzle on the steel pipe header of a boiler by inserting a nipple through a hole bored in the side of the pipe header for a driving fit, and flaring the interior projecting end, and then subsequently welding to the header around its outside circumference for steam tightness, the metal in the pipe header being of a lesser thickness than that required to make an expanded joint?

Reply: It is the opinion of the Committee that this method of of forming an outlet nozzle on a pipe header, does not meet the requirements of the Rules in the Boiler Code, which sanction the use of autogenous welding only where the strain is carried by other construction conforming to the requirements of the Code.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

Research Needs

DR. W. R. WHITNEY, Director of the Research Laboratory of the General Electric Company, writes regarding the need of developing research men and the importance of holding those who have demonstrated their ability in research in this field. He suggests the possibility of the Society's aiding by financial support in the following way:

I have also felt, in the case of our Chemical Society, that if it could raise the money to insure at least one pure research investigator a year, it could scarcely find a better way of advancing the science. I thoroughly believe that there is nothing which could do as much good for American science as to pick out a few good, young students, and by cold cash insure their continuance in pure and independent scientific work. This might be called the personal method, but I am sure that I have already noticed, in watching men, that a good man can do wonderfully good work in the advance of science or engineering if it can be arranged that he devote his entire attention to it with either a fair outlook or an assurance of safety on his part.

Erratum

In the description of the Thermal Testing Plant of the Experiment Station of Pennsylvania State College on page 464 of MECHANICAL ENGINEERING for May, the statement that the Tagliabue thermostats hold room temperatures within 5 deg. should read 0.5 deg.

A—Research Results

Cement and Other Building Materials A1-19 Tests on Kansas Sands for Use in Mortar and Concrete, by R. A. Seaton and I. I. Taylor. Bulletin No. 3, Engineering Experiment Station, Kansas Agricultural College. Address Director A. A. Potter.

Results of experiments show that all samples met the requirements of the joint Committee on Concrete and Reinforced Concrete from the four national engineering societies. Thirty-two of fifty-two samples have to be used with a small excess of cement. Only one sand had more than 6 per cent of its sample pass through a 100-mesh sieve. The sands in general were well graded.

Cement and Other Building Materials A2-19 An Investigation of Blended Portland Cement, by E. S. McCandliss and H. H. Armsby, School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Electric Power A1-19 Electric Cooking Appliances, R. G. Kloeffler, Bulletin No. 9, Engineering Experiment Station, Kansas Agricultural College, Manhattan, Kan. Address Dean A. A. Potter.

Advantages of electric cooking: safety, cleanliness, convenience, excellent results. First appliances exhibited in London, 1891. A cooked banquet to Lord Mayor of London, 1894.

$$\text{Efficiency} = \frac{\text{change in temperature} \times \text{lb. of water}}{3415 \times \text{kilowatt-hours.}}$$

Electric Irons: 0.97 kw-hr. for ironing wash for family of two; 1.25 kw-hr. for 70 pieces, family of six. Iron disconnected 28½ per cent of time.

Electric Toasters: 0.11 kw-hr. to make eight pieces of toast.

Coffee Percolators: about 0.08 kw-hr. to make five cups of coffee; efficiency 72 per cent.

Electric Grills: 0.10 kw-hr. for eight pieces of toast; efficiency 39 per cent.

Chafing Dishes, efficiency 60 per cent.

Immersion Water Heater, efficiency 80 per cent.

Cost of breakfast of 5 cups coffee, 4 slices of toast, 2 slices of bacon, 2 fried eggs, 0.19 kw-hr.

Electric Ranges: Efficiency range from 32 to 60 per cent.

Cost of cooking for a week (comparative values): 20.7 kw-hr., 320 cu. ft. of gas, 70.25 lb. of coal, 2 gal. of kerosene.

Foundry Equipment, Materials and Methods A1-19 Silica Refractories. Factors affecting their quality and methods of testing the raw materials and finished ware. Technologic Papers of the Bureau of Standards No. 116. Address Director S. W. Stratton, Bureau of Standards, Washington, D. C.

The work of this paper was carried out to obtain by simple, accurate means the degree to which the amorphous silica is gradually transformed to crystal forms of lower specific gravity when bricks are burned. Points concerning raw materials and methods of manufacture are touched upon as possible improvements. Molding with a pressure of 1500 lb. per sq. in. after mixing of sized materials in a batch mixer. The experiments show that the best method to burn is to raise the temperature to 1250 deg. cent. in the usual manner and then keep it between 1250 and 1350 deg. for several days, at the end of which time it is raised until the Orton pyrometric cones from 18 to 20 bend over. The specific gravity and porosity of most of the leading varieties of silica brick have been determined. They vary between 2.650 and 2.270 with an average of 2.384. The porosity varies from 22.6 to 31.5 per cent. The investigations show that the specific gravity between 2.65 for quartz and 2.270 for tridymite crystals indicates the degree to which the brick has been burned.

Foundry Equipment, Materials and Methods A2-19 Molding Sand. A method to determine the optimum water content of molding sands consists of adding an excess of water and whirling the mixture in a centrifuge. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Fuels—Gas, Tar and Coke A1-19 Preliminary Studies of Missouri Cannel Coal, by H. L. Dunlap. School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Address Director.

Iron and Steel A1-19 Purification of Magnetite Ore Containing 4 per cent Sulphur—Commercially Successful Process of Purification to 0.10 per cent. Pittsburgh Testing Laboratories, Pittsburgh, Pa.

Mathematics A1-19 Physical Quantities. A Relation Connecting the Derivatives of Physical Quantities. Applying dimensional calculations used in wind tunnels to other problems as those in predicting errors in instruments. Scientific Paper, Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Metallurgy and Metallography A1-19 Aluminum and Its Light Alloys. Bureau of Standards Circular No. 76. Bureau of Standards, Washington, D. C. Address Director.

Metallurgy and Metallography A2-19 Bibliography on Roasting, Leaching, Smelting and Electrometallurgy of Zinc, by H. L. Wheeler. School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Address Director.

Metallurgy and Metallography A3-19 The Effect of Addition Agents in Flotation, by M. H. Thornberry and H. T. Mann. School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Address Director.

B—Research in Progress

Air B1-19 A Commercial Method for the Measurement of High-Pressure Air Flow (100 lb. per sq. in. gage). H. S. Dickerson, School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Apparatus and Instruments B3-19 Measuring Device for Effective Diameter of Thread Ring Gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments B4-19 Lead-testing Machine for Threads. Improvement of apparatus shown in Figs. 3 and 4, page 412, of MECHANICAL ENGINEERING, April, 1919. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments B5-19 Balanced Micrometer Holder. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments B6-19 Specific Gravity of Finely Powdered Materials. A new method to obviate difficulty due to the presence of air. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Chemistry, Organic B1-19 Preparation of Anhydrous Oxalic Acid by Use of Buffalo Vacuum Self-Drier. W. D. Turner and P. D. Wilkinson, School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Chemistry, Organic B2-19 Preparation of Tri-methyl-amine by Means of J. P. Devine Autoclave at 650 to 700 Lb. per Sq. In. from Methyl Alcohol and Ammonium Chloride. W. D. Turner and B. G. Nichols, School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Economics B1-19 Cost and Accounting. System for a Machine Shop. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. W. W. Bird.

Electric Power B2-19 The Efficiency of Coal, Kerosene, Gasoline and Electric Water Heaters. Engineering Experiment Station, Kansas Agricultural College. Address A. A. Potter, Manhattan, Kan.

Heat B4-19 Resistance of Air to the Transmission of Heat. Engineering Experiment Station, Kansas State Agricultural College. Address Dean A. A. Potter, Manhattan, Kan.

Heat B5-19 Heat Transmission Through the Various Insulating Media. Engineering Experiment Station, Kansas Agricultural College. Address Dean A. A. Potter, Manhattan, Kans.

Hydraulics B2-19 Weir Coefficients. Determination of coefficients for 10-ft. weir. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. C. A. Allen.

Internal-Combustion Motors B4-19 Temperature of Oil Films and Various Parts of Engines During Operation. Determination of flame propagation and temperature within cylinder. Preliminary measurements on single-cylinder Liberty engine. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Internal-Combustion Motors B5-19 Fuel Consumption of Ford Engine with Different Adjustments of Stock Carburetors to Demonstrate Fuel Saving. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Leather and Glue B1-19 Leather Belting. Relative capacity of various materials to transmit power. Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Lubrication B3-19 An Investigation of Various Cylinder Lubricating Oils. Engineering Experiment Station, Kansas Agricultural College. Address Dean A. A. Potter, Manhattan, Kan.

Machine Tools B1-19 Twist Drills. Point Thinning of Twist Drills. Used to reduce thickness of web so as to reduce thrust without weakening drill. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. W. W. Bird.

Machine Tools B2-19 Proper Drill Speeds for Given Feeds. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. W. W. Bird.

Metallurgy and Metallography B1-19 Determination of Cadmium in Zinc by Means of a Microscope. H. T. Mann and H. P. Gill. School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Metallurgy and Metallography B2-19 The Relation of Exact Pyrometric Control of Heat-Treatment Furnaces to the Efficiency of Drill Steel. C. Y. Clayton, School of Mines and Metallurgy, University of Missouri. Address Director, Rolla, Mo.

Road Materials and Equipment B2-19 Tests on Kansas Road Materials. Engineering Experiment Station, Kansas State Agricultural College. Address Dean A. A. Potter, Manhattan, Kan.

Steam Power B2-19 Coefficient of Friction of Low-Pressure Steam in Pipes. University of Michigan, Ann Arbor, Mich. Address Dean M. E. Cooley.

Transmission B5-19 Minimum Center Distance of Pulleys for Belt Drives. Relation Between Elasticity, Tension and Time Element. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. W. W. Bird.

Transmission B6-19 Windage of Belt Drives. Loss of Power Due to Skin Friction and Variation With Speed. Worcester Polytechnic Institute, Worcester, Mass. Address Prof. W. W. Bird.

C—RESEARCH PROBLEMS

Heat C1-19 Transmission of Heat Through Cast-Iron Pipes in Annealing Furnaces. Transfer of heat from waste gases at 1000 to 1400 deg. fahr. moving with a velocity of 1000 to 2000 ft. per min. Temperature of furnace between 300 and 500 deg. fahr. Address G. L. Ostgren, New Jersey Zinc Co., 55 Wall St., New York City.

Light C1-19 Optical Surfaces. Improved methods of polishing optical surfaces, including metals, glass, rubies, etc. Address F. G. Pease, Mt. Wilson Solar Observatory, Cal.

Photography C1-19 Speed of Photographic Plates. Mt. Wilson Solar Observatory is desirous of having plates of higher speed. The time required for exposure with 72-in. reflector is 1½ hours. F. G. Pease, Mt. Wilson Solar Observatory, Cal.

Properties of Engineering Materials C1-19 Steam Packings. Relative value of steam packings, red packings, black packings, packings with more than 30 per cent rubber. Asbestos rubber packings. Frederick Dannerth, 325 Academy St., Newark, N. J.

Properties of Engineering Materials C2-19 Elastic Limit of Small-Size Commercial Drawn Tubing of Various Materials in Tension, Compression and Torsion. Harrison Safety Boiler Works, Philadelphia, Pa.

Properties of Engineering Materials C3-19 Hysteresis of Metals Under Reversed Stress and Torsion. Harrison Safety Boiler Works, Philadelphia, Pa.

Properties of Engineering Materials C4-19 Fatigue of Metals Made in Small Tubes. Harrison Safety Boiler Works, Philadelphia, Pa.

D—RESEARCH EQUIPMENT

Aircraft D1-19 Wind Tunnels, Washington Navy Yard. One tunnel 8 ft. square with maximum velocity of 80 miles per hour. Liners can reduce this to 8 x 4 ft. or 4 x 4 ft., giving wind speeds of 150 or 200 m.p.h. Tunnel equipped with Eiffel-type balance of 30 lb. capacity. A three-dimensional balance is being designed. One wind tunnel is 4 ft. square with maximum wind speed of 65 m.p.h. Small tunnel equipped with balance of Curtiss Engineering Corporation, capacity 20 lb. Address Commander McEntee, Navy Yard, Washington, D. C. (see RESEARCH PERSONAL NOTES, *Marine Engineering E1-19*).

Pittsburgh Testing Laboratory D1-19 This laboratory is equipped for chemical and physical tests in industrial chemistry and mine operation; tests of ores, fuels and raw materials; cement, sand and stone and concrete structures; inspection of asphaltic and other paving materials with portable

laboratories; inspection at mills and shops for bridges, buildings, shops, cars, locomotives, machinery, rails and inspection of steel and cast-iron pipes; testing of power plants and pumping plants. Address Pittsburgh Testing Laboratory, Pittsburgh, Pa.

University of Illinois D1-19 The equipment of the mechanical laboratory.

Steam Boilers
- 210-boiler hp. Heine boiler
- Foster superheater of 3400 sq. ft.
- Sturtevant economizer
- Kewanee down-draft smokeless house-heating boiler
- Small Arco cast-iron steam-heating boiler
- One Mercer cast-iron sectional steam-heating boiler

Steam Engines
- 7 x 10-in. and 10 x 12-in. Chandler & Taylor cross-compound engine with surface condenser
- Two 10 x 10-in. Ideal engines
- One 8 x 12-in. Meyer automatic engine
- One 8 x 18-in. Murray Corliss engine
- One 12 x 24-in. Allis-Chalmers Corliss engine belted to a 100-kw. generator
- One 60-hp. Kerr turbine
- Two 100-kw. Curtis turbo-alternators

Pumps
- One 300-gal. 150-lb. Fairbanks pump
- One 140-gal. two-stage DeLaval turbo pump

Main Steam Piping
- Steam piping is arranged to deliver saturated and superheated steam to any of the above units

Small Power-Plant Group
- 25-hp. portable boiler with 7 x 10-in. Atlas steam engine with feedwater heater, boiler-feed pumps, water meter

Heating and Ventilation
- Four-unit steam-radiator testing plant
- Experimental hot-blast heating unit with each section arranged for individual determination of condensation
- Warren, Webster & Co. air washer with temperature and humidity control
- Fans with facilities for making traverses of air duct and with fan driven by Sprague electric dynamometer
- Heat-transmission plant for finding heat through building materials
- Warm-air-furnace testing plant equipped for measuring temperatures, air velocity, effect of register faces, leaders and stacks

Air Compressor
- Two-stage 12¼-in. and 18¼ x 12 in. Ingersoll-Sargent compressor

Refrigeration Equipment
- Ten-ton York ammonia compressor
- Ten-ton Vogt absorption refrigerating machine with ice-making equipment and apparatus for measuring refrigerating effect

Internal-Combustion Engines and Gas Producer
- Two four-cylinder motors
- One six-cylinder motor
- One Sprague dynamometer of 150-hp.
- One 10 x 19-in. Otto engine
- One 5¾ x 12½-in. Otto engine
- One 9 x 9-in. Bogart engine
- One 9 x 10-in. Mietz and Weiss engine
- One 10 x 20-in. tandem Sargent engine
- One 75-hp. Smith producer

University of Kansas D1-19 The equipment in the mechanical laboratory of the University of Kansas is as follows:

Steam Equipment
- One 100-hp. Stirling boiler, hand-fired, with induced draft
- One superheater
- One 10 x 24 x 30-in. cross-compound Corliss engine
- One 20-hp. DeLaval turbine driving circulating-water pump
- One 75-hp. Ball engine, high-speed
- One Wheeler condenser, 500 sq. ft., with electrically driven wet vacuum pump and Mullen dry vacuum pump
- One equipment for demonstrating steam equipment and for exercises on same
- Power-developing units, including high-speed steam turbine, cross-compound high-speed engine, condensing, and boiler equipped with stokers available for commercial tests

Gas Equipment
- One 75-hp. tandem single-acting gas engine
- One 5-hp. Olds gas engine
- One 12-hp. I. H. C. oil engine
- One Ford automobile engine
- One 75-hp. Smith gas producer

Refrigeration
- One 5-ton Cleveland ammonia compressor

Small Equipment
- Gages, indicators, oil and friction testing machines, gas-analyzing apparatus, fuel calorimeters, steam calorimeters, speed counters, etc.

University of Missouri, School of Mines, D1-19 The Laboratory of the School of Mines, University of Missouri, includes the following equipment:

Boilers
- Four 130-hp. Heine safety boilers with soot blowers and measuring apparatus.

Engines and Generators
- 10-hp. Wickes boiler and engine plant
- 75-kw. Erie-Ball engine and Westinghouse d.c. generator
- 50-kw. Ideal engine with Westinghouse d.c. generator
- 50-kva. General Electric marine-type engine with a.c. generator
- 10-kw. General Electric turbo-generator
- 36-hp. Kerr steam turbine
- 9 x 14-in. Brownell engine
- 5 x 7-in. Davis & Rankin engine
- 21-hp. Otto engine
- 3-hp. Ferro gas engine
- 8-hp. Bessemer gas engine
- 6-hp. Continental automobile motor

Pneumatic Equipment
- One Laidlaw-Dunn-Gordon air compressor
- One Rand Imperial air compressor
- One Sullivan air compressor
- One 36-in. Sirocco blower
- One 72-in. Buffalo fan
- One 62-in. Buffalo blower
- Air tanks.

Testing Machines
- 200,000-lb. tension, compression and bending machine
- 60,000-lb. Olsen torsion machine
- 50,000-lb. Riehlé machine

Mining Equipment
- 42-in. furnace with coal, gasoline and coke
- 20-in. blast furnace
- One gyratory breaker and one Dodge breaker
- One pair of rolls
- Two plane shaking screens, three trommel screens
- One duplex Callow belt screen
- One 3½-ft. Huntington mill and one three-stamp mill
- Two Vezin samplers.
- One Richards pulsating classifier, three-spigot cone classifier, four-spigot classifier, Tamarack classifier
- Four settling cones
- Three 5-cell Herz jigs and one pulsator jig
- Tables for sands: one Card, one Deister-Overstrom, one James, and two Wilfley
- One 4-ft. Frue vanner
- One 5-ft. Sperry slimer
- Breakers, grinders, and rolls with bucking boards, mullers and tube mill.

Drills
- Two Ingersoll-Rand, two Sullivan, one Wood, one Leyner, one Stoper, one Waugh, and one Sullivan. Ingersoll Rand jackhammer, one Hardsoeg, one Cleveland, one Fort Wayne Electric, One Scott gas.

Shops
- Pattern shop
- Forge shop
- Foundry
- Machine shop.

E—Research Personal Notes

General E4-19 Steel Treating Research Society.

The American Steel Treaters' Society, with headquarters at Chicago, Ill., T. E. Barker, President, and Arthur G. Henry, 154 East Erie St., Chicago, Ill., Secretary, is doing work along the lines outlined in the March, 1919, number of MECHANICAL ENGINEERING. The Chairman of their Research and Standards Committee is Thos. E. J. Janitzky, Illinois Steel Co., South Chicago, Ill.

Lynite Laboratories E1-19

The Lynite Laboratories of the Aluminum Castings Company, under R. E. Carpenter, Manager, are divided into a Research Division under Dr. Z. Jeffries and a Development Division. The Research Division is divided into Sections of Special Research, Metallurgy, Metallography, Chemistry, Physics, and Tests, while

the Development Division is divided into Sections on General Engineering, Automotive Engineering, Permanent-Mold Section, Sand-Casting Section and a Forging Section. The plan of the laboratory is to connect the experimental work with the production work of the country. Address R. E. Carpenter, 2800 Harvard Ave., Cleveland, Ohio.

Marine Engineering E1-19 Use by Private Parties of Naval Experimental Basin.

The Naval Experimental Basin at Washington, D. C., is available for testing models or other devices for private parties provided the expense is borne by the parties and the work does not interfere with Government work. No profit is made, but actual cost to Government is charged. Apply to the Bureau of Construction and Repair, Navy Department, Washington, D. C.

F—BIBLIOGRAPHIES

Air F1-19 Air Conditioning. Cooling-Spray Ponds and Nozzles. Bibliography prepared for Research Committee. Address A.S.M.E., 29 West 39th St., New York.

Hydraulics F1-19 Air-Lift Pumps. Bibliography prepared for Research Committee. Address A.S.M.E., 29 West 39th St., New York City.

Hydraulics F2-19 Cooling Water. Cooling-Spray Ponds and Nozzles for Air Conditioning. Bibliography prepared for Research Committee. Address A.S.M.E., 29 West 39th St., New York.

Materials of Engineering F1-19 Bearing Metals. Bibliography prepared for Sub-Committee. Address A.S.M.E., 29 West 39th St., New York City.

REPORT OF SUB-COMMITTEE ON LUBRICATION

RESEARCH COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE Sub-Committee on Lubrication has recognized certain problems as definitely awaiting solution. Among these problems are those relating to the behavior of lubricants at high pressures and temperatures. The conditions existing in bearings operating under moderate pressures, with therefore relatively thick oil films, are fairly subject to analytical treatment based on the assumption that the viscosity of the lubricant is the sole factor affecting its operation. On the other hand, under conditions of very high pressures or high temperatures or both, it is a common experience that certain organic oils, e. g., lard oil and sperm oil, are much more effective in reducing friction than are mineral oils of similar viscosity, as ordinarily measured. The property or properties causing such differences in lubricating value are at this date more or less obscure. Various terms have been used in recognition of the existence of this lubricating property, such as "oiliness," "greasiness," "unctuosity," "body," etc., but thus far no conclusive experimental evidence has been obtained to show the nature of the physical processes accounting for the observed differences in lubricating value. In discussing this general problem the Committee has recognized the following lines along which investigation might be conducted:

1 *Effect of Pressure Upon Viscosity.* It has long been known that high pressure produces measurable changes in the viscosity of certain fluids. Mr. M. D. Hersey[1] has experimented on this subject, using the ball-and-tube type of viscosimeter described by Prof. A. E. Flowers[2]. Mr. Hersey found that lard oil and (mineral) machine oil, of nearly the same viscosity at atmospheric pressures, showed great increase in viscosity under pressures of 200 to 500 atmospheres. Further experiments in this direction are desirable.

2 *Effect of Temperature on Viscosity.* It is well known that all lubricants decrease in viscosity with increase of temperature, and also that certain organic oils, notably sperm oil, decrease relatively less than the mineral oils. Under very high pressures, such as occur with metal-cutting tools, the temperature of the effective portion of the lubricant may be very high. Viscosity measurements are rarely made at temperatures above 100 deg. cent., but this temperature is probably much lower than that actually reached in severe service; hence, it is desirable to experiment on the viscosities of lubricants up to the temperatures of volatilization or of disintegration.

3 *Adhesion (Capillarity).* Experiments have thus far not shown slipping at the boundary surface between the lubricant and the solid surfaces at moderate rates of shear in the lubricant; but it is still a question whether such slipping may not occur under excessive rates of shear, such as may exist when the film is exceedingly thin. Mr. Albert Kingsbury has experimented with a device consisting of a slightly tapered plug rotating in a ring, the parts being of hardened steel, closely fitted by grinding. The thickness of the oil film between the surfaces was determined by micrometric end adjustment of the plug. With films as thin as 0.000025 in. and rates of shear up to 261,000 radians per sec., at atmospheric pressure and temperature, there was no indication of slip, and no deviation from the ordinary law of viscosity that could not be attributed to inaccuracy of the fitted surfaces. It is possible that some form of experiment might be devised which would extend our knowledge in this direction. If slipping should be shown in any case, there would further arise the question whether it depends on the nature of the bearing metals.

4 *Adsorption.* The suggestion is made that the lubricants that exhibit oiliness in a marked degree may contain solids in solution, which tend to concentrate at the boundary surfaces, thus increasing the viscosity at the surface, and therefore enhancing the lubricating value under conditions of very high pressure. There is at this date no direct evidence on this point, except in the case of the use of soap dissolved in the water used in hydraulic cylinders, the soap being found to concentrate upon the metal surfaces, forming a good lubricating film.[1] It is possible that this may account for the good lubricating properties of the various "cutting mixtures" containing soap and water, used for lubricating metal-cutting tools; and possibly the valuable properties of lard oil and of sperm oil, for examples, may be due to similar phenomena.

ALBERT KINGSBURY, *Chairman.*
ALAN E. FLOWERS.
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GEORGE B. UPTON.
Sub-Committee on Lubrication.

[1] *Journal of the Washington Academy of Sciences*, Vol. VI, 1916, p. 525.

[2] *Proceedings of the American Society for Testing Materials*, Vol. XIV, Part II, 1914.

Tentative report for presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

REPORT OF SUB-COMMITTEE ON BEARING METALS

RESEARCH COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

IN THE January number of MECHANICAL ENGINEERING, our Committee made a brief report giving concisely the reason for abandoning our original plan of first publishing a complete compendium of the technical literature on bearing metals. At the time we also pointed out what we considered the most promising outlook for future study and investigation.

It is our conviction that a large amount of valuable time is being wasted in testing bearing alloys, in determining characteristics that are of no consequence and are utterly meaningless. The only mechanical or physical test of a bearing alloy, in the

[1] Lubrication and Lubricants—Archbutt and Deeley (Lippincott).

Tentative report for presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

aggregate, that can serve any useful purpose is that of determining whether the given alloy has a sufficiently high factor of safety against possible distortion or rupture under specified service conditions at service temperature. All other characteristics are of a microscopic nature, depending entirely upon the properties of the individual crystals of the alloy, upon their orientation, relative hardness, fusing temperature, quantitative proportions and the like.

Our studies have convinced us that any work on our subject without the application of modern metallography is an absolute waste of time; we also feel that studying the hardness of the individual microscopic crystals is of the greatest importance in supplementing the application of metallography to our subject.

The instrument shown in our last report has been perfected to a much higher degree and three of them have been substantially completed, one for each member of our Committee. This instrument determines the characteristic of a crystal which is the combination of three of the five fundamental conceptions of hardness[1]; namely, the combined effect of cutting hardness, scratch hardness, and penetration hardness. This is done by very slowly moving an exceedingly hard and sharp point[2] under a definite pressure, over a highly polished surface of the crystal to be tested; in fact, the point is moved so slowly that no additional penetration is effected by stopping. The point is a solid right angle or the corner of a cube, mounted in such a manner that the diagonal of the cube will be normal to the surface tested, and having an edge of the cube advance directly in the line of motion. The motion is effected by a slow micrometer feed. The width of the cut, scratch, or penetration is a function of its depth and, therefore, measuring the width of the mark gives us the means for determining this combined characteristic representing the hardness of any crystal. The instrument is properly called a *Microcharacter*.[3]

In order to lay the broadest foundation for our work, one that will facilitate the coöperation of other investigators and will make all results directly comparable, it is necessary that conventional units be established; that is, that a *Scale of Microhardness* be determined upon. With the establishment of this scale it will be possible to consider the various crystals in the many different alloys in terms of exact degrees of hardness. This is the work that occupies the attention of your Committee at the present time.

Experience well shows that a single homogeneous metal is not suited for bearing purposes, and that the first requirement for a bearing metal is that it be an alloy composed of at least two metals, or a metal and a metalloid, which shall have at least a limited degree of solubility while in the molten state; but that upon cooling it shall partially separate out into dissimilar crystals, and thus form the proper microstructure which is necessary in all bearing alloys. It is not only necessary that a bearing alloy shall be composed of chemically dissimilar crystals, but it is all-important that these crystals shall have a marked degree of difference in their physical hardness and wearing qualities.

The degree of relative solubility necessary for the constituents of bearing alloys is well illustrated by the copper-tin and the copper-zinc compounds, and this also illustrates why bronze is a better bearing alloy than brass. For example, with the addition of not more than 11 per cent of tin to copper, a three-phase alloy is ordinarily produced—less than a two-phase alloy cannot be produced; even with the most instantaneous chilling effect, crystals of different chemical composition are produced. While on the other hand, with 11 per cent of zinc added to copper only a single-phase alloy can be produced, however slowly it may be cooled; that is, all of the crystals in this copper-zinc alloy are of the same chemical composition, and therefore all have the same physical properties. Quite the opposite is true in the copper-tin alloy, an extreme dissimilarity of crystals existing both as to chemical composition and physical hardness. Now, it is due entirely to this dissimilarity of crystals in the bronze that makes it a better bearing alloy than brass.

In the solidifying of the molten bronze the tendency of the tin to separate from the copper is far greater than that of the zinc in the solidifying of brass, for the reason that the bronze solidifies with a distinct microscopic heterogeneity. The matter of having a proper microstructure in a bearing alloy is always of far greater importance than its exact aggregate chemical composition. The value of an exact or definite chemical composition is secondary, in that it can serve only in producing the desired microstructure in a given alloy, provided the alloy is subjected to the proper cooling conditions.

The essential characteristics of all bearing alloys is a structure made up of alternately hard and relatively soft microscopic particles intimately mixed. The function of the hard particles or *bearing crystals* is to support the load and resist the wear. These bearing crystals should not be hard enough to prove distinctly abrasive to the journal surface. General experience shows that an extreme hardness of the bearing crystals is characterized by an excessive wear of the journal. The function of the softer or more readily abraded crystals is that of being plastic and permitting the bearing crystals to adjust themselves to surface requirements of the journal. These softer crystals are also more readily abraded, and therefore wear slightly below the surface of the bearing crystals and thus form slight depressions upon the bearing surface which serve for the retention of the lubricant. However infinitesimal in amount this may seem, nevertheless it is this lubricant that prevents scoring or seizing when the journal is starting up from rest at a time when actual metallic contact between the bearing surfaces exists. The same is equally true under an excessive load. This function of retaining a slight quantity of the lubricant upon the bearing surfaces when metallic contact exists, characterizes a bearing alloy in its truest sense. Therefore a bearing metal may be defined as: *An alloy that is capable of retaining a lubricant on a bearing surface.*

In the operation of a bearing under normal conditions, when a continuous and unbroken film of lubricant exists it matters little what metals are used while the film is sustaining the entire load. In the starting and stopping of the journal, however, or at all such other times when the film is interrupted and metallic contact exists, it then becomes very important that the properties of a bearing metal should be present.

A matter of importance, which seems not to have been considered heretofore, is the fusing temperature of the bearing crystals. From observations made it is evident that under severe conditions where relatively low-fusing bearing crystals exist in a high-fusing alloy these bearing crystals actually fuse on their surfaces during the process of the "running in" of the bearing. The delta copper-tin crystal (Cu_4Sn) may be cited as a particular example, and in some severe conditions corresponding to automotive worm-drive service the alpha copper-phosphorus crystal (Cu_3P) seems to function in a similar manner. It is doubtful whether these conditions ever obtain in any of the babbitts, since their bearing crystals are the highest-fusing compounds of these alloys.

The study of bearing metals is very incomplete unless these alloys are considered in conjunction with the other corresponding bearing member. The extreme variety of modern steels makes this necessary, since a bearing alloy suited for a soft low-carbon machine-steel journal would not be an economic selection for a high-carbon nickel-chrome heat-treated journal, and a proper selection for the latter would prove destructive for the former.

It seems exceedingly improbable that laboratory accelerated service tests can ever give general satisfaction owing to the difficulty of reproducing in a few hours' time the equivalent of many years of service conditions. It is our conviction that much more can be learned from the study of failures, and also in studying old bearings (together with their journals) which have given eminently satisfactory service for an exceptionally long period.

C. H. BIERBAUM, *Chairman*
J. A. CAPP
H. DIEDERICHS
Sub-Committee on Bearing Metals.

[1] General Metallurgy—Hofman.
[2] MECHANICAL ENGINEERING, Jan., 1919, p. 71.
[3] μικρο'σ, small; χαράσσειν, to engrave, or scratch.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

Pressure Governor for Gas Exhaustprs and Boosters
Instrument for Measuring Combustible Gas in Air
Balloons and Solar Radiation
Soaps, Specifications and Testing
Malleable Cast Iron and Phosphorus
Carbon Steel, Heat Treatment of
Dilatometer Methods and Instruments
Chavenard Differential Dilatometer
Case-Hardening and Application of Heat
Case-Hardening and Temperature Measurement by Color
Heat Treatment of Bronze Castings
Safety Regulation on Pressure Piping
Bouchayer and Viallet Safety Regulator for Pressure Piping
Engine Tests and Atmospheric Humidity
Sykes Flexible Reversible Coupling
Rigidly Connected Reinforced-Concrete Frames
Interconnection of Central Plants and Steam Reserve
High-Pressure Steel Economizers
Submersible Salvage Pumps and Engines
Water Treatment on Railroads
Explosion of Compressed-Gas Cylinders

AIR MACHINERY

Governor for Regulating Pressure of Gas Exhausters and Boosters. Description of a new device designed to react instantaneously upon slight changes of pressure applied to the governing of rotary exhausters. To comprehend it thoroughly, it is necessary to understand the difference between throttling regulation and cut-off regulation.

In a rotary exhauster working within the limits of intake and discharge pressure the work done by the engine per revolution is constant as long as the elements are constant.

If two engines work side by side, one regulated by a throttling governor and the other by a cut-off governor the indicator cards will be as shown in Fig. 1. In the case of throttling regulation any increase in the speed of the engine will have a given position of the governor result in a greater throttling loss and in less work per revolution. With a cut-off regulation if the engine speeds up the work per revolution remains practically constant and no large force is required to return the speed to normal unless that force comes from the engine governor.

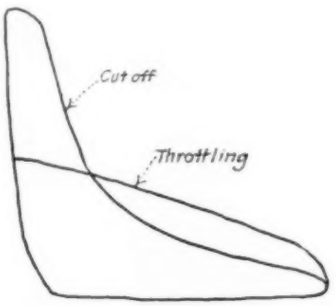

Fig. 1 Indicator Card for Two Engines, One with Throttling and the Other with Cut-Off Regulation

In gas exhausters, particularly in connection with by-product extraction, the pressure at the exhauster must be kept constant within 5 mm. of water, which means a closeness of regulation of 0.05 per cent, or, roughly, 100 times as much as in compressor practice.

The new governor shown in Fig. 2 is of the float type. It is equipped with a stabilizing chamber which is partly filled with water to prevent it from following the influence of the pressure too far. (Should the float tend to rise under the influence of less vacuum inside of it, the water in the stabilizing chamber is lifted so that the float becomes heavier and resists being carried too far.) To enable the float to find its correct position the stabilizing chamber is purposely made leaky, the extent of the leak being determined by an adjustable valve, of which the screw is shown at 3. With the valve wide open the governor surges; with the valve dead shut it does not maintain a constant pressure.

The motion of the float is communicated to a vertical pilot valve 1 by means of light rods with very small pin joints which approach frictionless knife edges in their action. The pilot valve is equipped with a compensating return mechanism provided to prevent slight displacements of the valve from moving the valve gear of the engine continuously away from the starting position

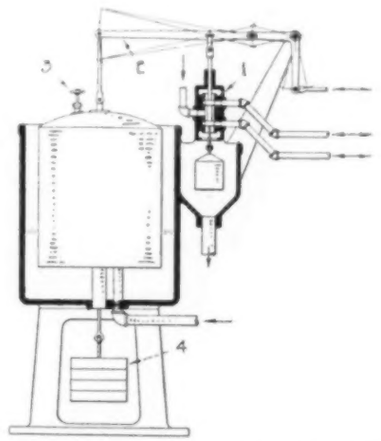

Fig. 2 Section of the Roots Pressure Governor for Gas Exhausters

until the resulting speed change and pressure change move the governor and displace the pilot valve in the opposite direction.

The lever 2 is so connected with the valve gear that motion of the latter induced by opening of the pilot valve closes it.

It has been found by experiment that with releasing gear for Corliss or poppet valves 3 mm. total fluctuation of suction pressure can be obtained, except during periods of excessively quick changes in the various pressures and gas volume when the pressure fluctuation will reach 10 to 15 mm. of water. (*The Iron Trade Review*, vol. 64, no. 17 April 24, 1919, pp. 1086-1087, 2 figs., *d*)

BUREAU OF STANDARDS

New Instruments for Measuring Combustible Gas in Air

New Forms of Instruments for Showing the Presence and Amount of Combustible Gas in the Air, E. R. Weaver and E. E. Weibel. A study has been made of the combustion of small amounts of gas in the air at the surface of electrically heated wires and the application of this phenomenon to the design of instruments for the purpose of detecting the presence

and indicating the amount of combustible gas in the air. As a result of this study three types of instruments, each especially adapted to certain uses, have been designed, tested and found to work satisfactorily.

The action of one of these instruments depends upon a resistance change, one upon a heating effect upon an adjacent bimetallic strip, and one upon the light emitted from the heated wire.

A discussion of the principles involved in the design of the instruments and specifications for their construction are given. (Abstract from Scientific Paper No. 334)

Solar Radiation as It Affects Balloons

EFFECT OF SOLAR RADIATION UPON BALLOONS, J. W. Edwards and M. B. Long. This paper describes briefly the effect of solar radiation upon balloons and includes experimental measurements on typical balloon fabrics.

Preliminary to the subject proper a summary is given of the characteristics of solar radiation and atmospheric conditions which have a direct relation to the problem. The radiation characteristics of the fabrics themselves are discussed. A series of measurements on representative balloon fabrics showed an absorbing power for solar radiation varying from 45 to 90 per cent.

The fundamental relations governing the temperature of balloon fabrics when exposed to solar radiation are outlined and the application of these to the calculation of balloon temperature is discussed. The multiplicity of factors involved makes the calculation of such temperatures of very limited value, but by means of measurements on a model balloon the magnitude and distribution of the temperature involved, in both gas and fabric, are well illustrated. The temperature of the upper surface of the model balloon in bright sunlight under certain definite conditions, varied from 20 deg. cent. to 39 deg. cent.

The importance of the radiation characteristics of fabrics in governing buoyancy changes, in causing increased permeability of the fabric to hydrogen and in its effect on the life of the fabric is emphasized as a factor in the selection of fabrics for various purposes. Other factors affecting the selection of fabrics are summarized and their relation to the radiation characteristics is pointed out. (Abstract from Technologic Paper No. 128)

Methods of Testing and Specifications for Soaps

SPECIFICATIONS FOR AND METHODS OF TESTING SOAPS. This circular includes a general discussion of the composition of soap and the varieties of toilet, laundry, scouring and soft soaps for which specifications are proposed. These specifications cover milled toilet soap, white floating soap, liquid soap, shaving soap, salt-water soap, special-grade laundry soap, ordinary-grade laundry soap, chip soap, soap powder, hand grit soap, scouring soap (A), scouring soap (B), and automobile soap. The methods described include those for sampling deliveries, for preparation of the laboratory sample and for the following tests and determinations: Matter volatile at 105 deg. cent.; free alkali or acid; alkali as alkaline salts; silicate; sulphate; matter insoluble in water (insoluble siliceous material); unsaponified saponifiable matter; preparation of total fatty acids; titer test; acid number of fatty acids; total alkali; chloride; rosin; total anhydrous soap; sugar (qualitative test); feldspar and quartz; potash and soda. (Abstract from Circular No. 62, 2nd edition).

ENGINEERING MATERIALS (See also Heat-Treating)

EFFECTS OF PHOSPHORUS ON MALLEABLE CAST IRON, J. H. Teng. Discussion based on experiments conducted at the University of Birmingham. Two series of test bars were prepared; one by adding phosphoric iron to a pure American wash white iron, and the other by adding the same to iron supplied by malleable-iron founders in Birmingham.

Tensile transverse and bending tests were made and Figs. 3 and 4 show the relation between transverse strength, deflection and the proportion of phosphorus in both types of irons.

In the tensile-strength tests it was generally found that the maximum stress elongation and reduction of area are gradually lowered with increasing phosphorus, while the yield point is gradually raised.

The bars belonging to the pure-iron series show a higher yield point but a lower maximum stress, a lower elongation and a smaller reduction of area than those belonging to the common-iron series, which may, however, be due to the higher silicon content in the former.

The following general conclusions were reached:

The addition of phosphorus does not result in any improvement in the mechanical properties of the malleable casting.

Any addition of phosphorus leads to a deterioration in the mechanical properties, as shown by tenacity, elongation, and toughness.

The ill effects of phosphorus do not become marked until about 0.2 per cent of phosphorus has been reached, and this

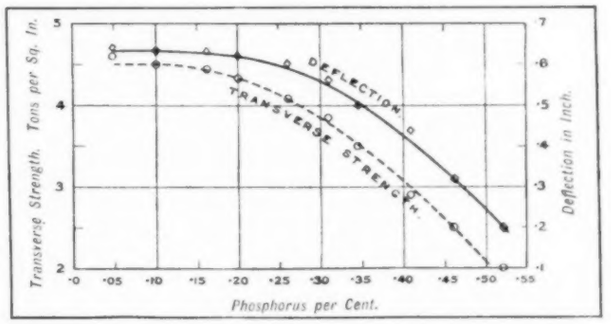

FIG. 3 CURVES SHOWING THE RELATION BETWEEN TRANSVERSE-STRENGTH DEFLECTION AND THE PROPORTION OF PHOSPHORUS IN THE PURE-IRON SERIES

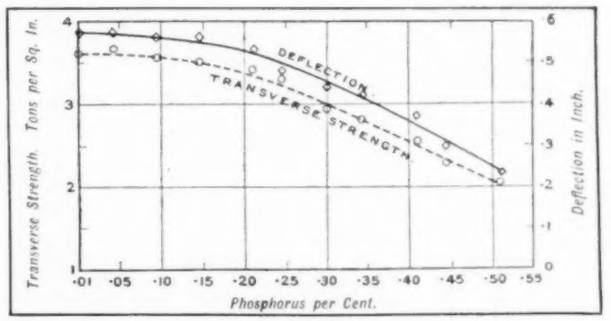

FIG. 4 CURVES SHOWING THE RELATION BETWEEN TRANSVERSE-STRENGTH DEFLECTION AND THE PROPORTION OF PHOSPHORUS IN THE COMMON-IRON SERIES

may be considered to be the approximate limit for commercial purposes.

The presence of a considerable amount of silicon and manganese is of more importance than the absence of sulphur with regard to the success of the annealing operation.

The origin of the sulphide of iron in the spent oxide is attributable to the presence of sulphur compounds in the reducing atmosphere in the furnace near 900 deg. cent. (Paper before British Iron and Steel Institute, reported through *Foundry*, vol. 47, no. 320, April 1, 1919, pp. 151-156, 9 figs., *e*)

HEAT-TREATING

Dilatometer Method of Investigating Heat-Treating of Carbon Steel

MECHANISM OF TEMPERING CARBON STEEL, Pierre Chavenard. An extensive discussion based on experimental research and abstracted from a recent issue of *Revue de Metallurgie*.

In order to observe in all details the transformation of steel during tempering and in order to connect in a quantitative manner the intensity of observed phenomena with other experimental conditions, it is necessary to have at every instant and in all points of the test piece under investigation the same temperature and hence the same rate of cooling.

For purposes of investigation little value must be placed on methods of thermal analysis, as their sensitiveness is proportional to the mass of the test piece and nearly independent of its shape. To this class belong all methods based on the study of temperature-time curves, variation of magnetic properties, etc. If, with these methods, very small pieces are used for purposes of investigation, certain details may remain unnoticed through lack of sensitiveness of the process employed. On the other hand, if large pieces of steel are used, there is a danger of the presence of excessively different conditions in various parts of the test piece.

Because of hysteresis phenomena, the use of electrical reactions for discovering changes of state of steel leads to considerable experimental difficulties.

The "dilatometer" method avoids all these pitfalls. The measurement of dilatation of a test piece refers only to one of its dimensions, and that is why in experiments made with a very fine wire it is sufficient to secure uniformity of temperature and rate of cooling in reference to its length. Moreover, the wire may be comparatively short (only a few centimeters long), because the transformation is accompanied by an important irregularity of dilatation, which it is easy to amplify materially by optical means. Furthermore, it is easy to secure uniformity of conditions of cooling, and finally the examination of the wire treated will, in the great majority of cases, enable one to verify in how far this uniformity has been actually secured.

The sensitiveness of this method is not only very high but it is practically independent both of temperature and velocity of reaction. This extremely important property makes it possible to disclose at low temperatures the most feeble manifestations of change of state from γ to α. Finally, the phenomena of dilatation are accompanied by the exercise of considerable forces with respect to which the inertia of the amplifying apparatus is quite negligible. Because of this, the readings of the dilatometer translate faithfully and without lag the maximum of transformation, no matter how great may be the velocity of cooling.

Of course, to cool a wire a few hundredths of a millimeter in diameter, immersion into a liquid was out of question, but the spontaneous cooling in an inert gas of a steel wire previously brought to red heat by an electric current may be rapid enough to produce tempering. In fact, according to a deduction from Newton's law, the velocity of cooling varies in inverse proportion to the diameter of the wire, and for a wire of small section attains a high value. In order to vary in a continuous manner the rate of cooling, resort is made to an experimental process based on the high heat conductivity of hydrogen. All other conditions being equal, the fall of temperature in hydrogen is about three times what it is in nitrogen, and mixtures of these two gases in various proportions provide a means of carrying out on the same test piece a series of temperings at various predetermined rates of cooling.

The extremely low mass of this test-piece wire appears to be an obstacle in the way of directly measuring the temperature during cooling, but this difficulty is circumvented by the use of a comparison wire made of "baros," a metal whose heat properties are very close to those of steel in the γ state. The two wires heated to the same temperature and then at the same time permitted to cool, will, with proper precautions, maintain the same temperature up to the beginning of transformation from γ to α. In the arrangement used by the author the expansion of a sample of baros measures its temperature and indirectly determines also the temperature of the steel sample.

The comparison wire permits also to employ the dilatometric method under a differential form, which gives it an extremely high sensitiveness. The apparatus based on that principle automatically draws a curve whose abscissæ represent the expansion of the sample and the ordinates the difference in the expansions of the two samples. This curve is recorded on a photographic plate, while the periodic interruption of the luminous ray marks the time in conformance with the principle previously employed by Le Chatelier. This makes it easy to compute the velocity of cooling at any point in the photographic diagram.

A question may be raised as to how far the conclusions drawn from a study of extremely fine wires may be applied to the case of commercial tempering of pieces having a considerable mass.

There is no doubt that fundamentally the phenomena must remain qualitatively the same notwithstanding the changes in the dimensions of the piece treated. On the other hand, however, it is certain that the magnitudes of the necessary rates of cooling for tempering are dependent on these dimensions. In fact, during rapid cooling of a large piece the central zones are subjected to a high pressure due to the contraction of the layers lying on the periphery and first reaching a low temperature. This pressure tends to oppose transformation from γ to α, which takes place with increase in volume.

In other words, the physical variables which determine for each element of volume of steel the occurrence of transformation

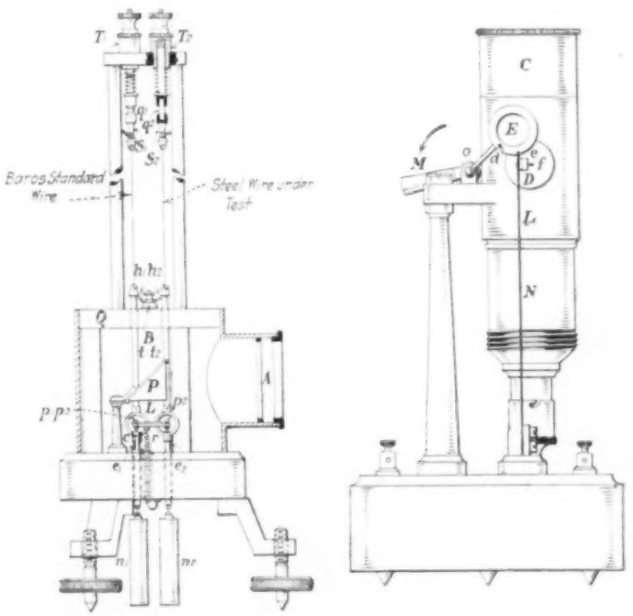

FIG. 5 CHAVENARD DIFFERENTIAL DILATOMETER

are temperature, pressure and their variations as a function of time.

In the present investigation the author leaves the action of pressure practically out of consideration. The rates of tempering measured by the method employed here are really the upper limits, but their determination is nevertheless of great interest because it enables one to classify different kinds of steel in accordance with their aptitude for tempering.

The whole article is too extensive for abstracting and because of this only the conclusions are reported here, in addition to which is given a description of the differential dilatometer employed in the present investigation.

The following conclusions are reached by the author:

In most reversible steels, such as the carbon self-hardening steels, the tempering occurs always in accordance with the same mechanism, even though the velocities of reaction necessary to obtain comparable states may be in two different cases extremely different from each other.

When the transformation in cooling takes place entirely at a high temperature, say, 600 to 700 deg. cent. (Ar'), it leaves the metal in a state of physicochemical equilibrium, state of anneal. In accordance with the rapidity of the change of state the steel may consist of pearlite or troostite.

The tempering takes place because of the fact that at low

temperatures (150 to 300 deg. cent.) there is a transformation from γ to α of the austenite. Its intensity is the greater in proportion as this transformation Ar'' is nearer to completion; when the tempering has been completed entirely the steel consists practically exclusively of martensite.

Between the two extremes of treatment, anneal and full temper, there may be had a series of semi-tempers due to the superposition in each elementary volume of steel (the linear dimensions of which are of the order of 0.01 mm.) of the transformation of anneal (Ar') and of temper (Ar''); the semi-tempered steels consist of troostite and martensite, or of ferrite and martensite.

The beginning of tempering is always clearly defined, while the disappearance of Ar', that is, the completion of the tempering, is a limited phenomenon, which sometimes proceeds quite slowly. If the energy of the treatment be carried out to exaggeration, the increase in the proportion of austenite is maintained in the steel and the efficiency of tempering is decreased.

Either by studying tempering on wires or by determining the magnitude of anomalous occurrence of cementite in treated steels, exact indications may be secured as to the nature of the constituents of tempering and annealing. Martensite, which is due to the transformation of austenite at low temperature, appears to be an unstable solid solution of carbon in α iron. Troostite in negative tempers, or half-tempers, osmondite and sorbite in anneal must be considered as aggregations of iron and cementite.

In order to obtain a steel of the same strength of temper recourse must be had to cooling, which must be the more rapid the less the heating was carried beyond the Ac state. If it be desired to obtain tempers of approximately equal strengths in different steels heated to the same initial temperature, the velocity of cooling which must be employed must increase in proportion to the decrease in carbon content. The experiments described in this paper have, it appears, for the first time led to a quantitative expression of these relations for the most simple cases, namely, infinitely small strength of temper and samples of negligible mass.

The ability of a steel to take temper may be defined quite precisely by the temperature of heating, the initial velocity and the limit curve of anneal. The determination of this curve is of essential theoretical and practical importance. Hitherto it could be obtained exactly only with self-hardening steels and the investigation of very reversible steels has been carried out to a much smaller extent because of the lack of a convenient and exact process for the determination of very high velocities of cooling.

The method of thermal analysis based on automatic record, of the dilatation of a steel wire during its cooling in an inert atmosphere appears to fill this need and the availability of an exact and convenient method for measuring the degree of irreversibility of steels opens a field for new investigations, one of the most important of which will have to do with the specific action of traces of elements which ordinary steels contain as impurities, or of special alloying elements which may enter into their composition.

Differential Dilatometer. In the dilatometer, Fig. 5, the steel wire as well as the standard wire having a diameter of 0.23 mm. are attached on the top to invar holding screws S_1 and S_2, which are in one piece with the suspension heads P_1 and P_2. These wires are held by invar rods t_1 and t_2 to the weights II_1, II_2, which give to the wires a tension of 0.5 kg. per sq. mm. (711.16 lb. per sq. in.). The suspension heads are so arranged as to permit an adjustment of the position of the wire, namely, the twist about its axis and a slow upward movement.

The dilatations of the wires are transmitted to the optical lever L, the purpose of which is to amplify them. This lever, provided with a flat mirror M, is carried on three tempered chrome-steel pin points p_1, p_2, p_3, arranged in a right-angled triangle. The dilatation of the wire gives to the optical lever a complex movement equivalent to two rotations; one about an axis OX, this rotation being proportional to the difference of the elongation of the two wires; and another around axis OY, proportional to the elongation of the standard wire. The curves traced by the ray reflected from the mirror enable reading the indications of the apparatus.

In order to compute the velocity of cooling the luminous ray is eclipsed periodically so that the photographic curve consists of a succession of interrupted lines, each of which has been drawn within the same time interval.

The original article describes in detail the method of using the differential dilatometer and the results obtained therewith. (Mechanisme de la trempe des aciers au carbone. Pierre Chavenard, *Revue de Metallurgie*, vol. 16, no. 1, January-February 1919, pp. 17 to 79, 17 figs., *etA*)

Troubles in Case-Hardening and Their Elimination

THE APPLICATION OF HEAT IN CASE-HARDENING, Theo. G. Selleck. The practical case-hardener has four important factors to consider: (1) the nature and quality of the material to be treated [laboratory reports of analyses or specifications from manufacturer], (2) temperature at which the material is treated, (3) the carbonizing agent, and (4) time.

The writer considers especially temperature and its uniform application, but points out that the nature and quality of the material to be treated are a prolific source of trouble for the case-hardener.

Steel is not always what it seems to be or what specifications and analyses show it to be. Chemical analysis of steel does not take into account mill faults which may be hidden in various segregations of elements nor does it always find variations of carbon beyond the limits of specifications which are not unusual.

The original article illustrates by photomicrographs cases of segregation which occurred in a steel plate supposed to carry 0.10 to 0.15 per cent carbon. The plate was carbonized and hardened, after which it proved to be very brittle.

Not only upon fracturing the plate did there appear to be no soft center, but in the center of the cross-section of the plate there were numerous little cracks expanding perpendicularly in the direction of the surface of the plate but not quite reaching it. Such conditions cannot be anticipated or determined in advance and often cause heavy loss of material and labor.

The cause of another mill fault frequently discussed in treating plates is that commonly known as lamination due to ferrite ghosts. The remarkable part of this fault lies in the fact that it occurs almost on the weld line or the line between the carbonized area and the soft center.

In addition to such segregations as have been referred to above and which are due to the previous history of the carbonized pieces, there are other segregations called by the writer "segregations of heat" for which the case-hardener is entirely to blame if they occur.

Heat is the primary element of all case-hardening. As iron must be in the gamma state before it can dissolve carbon, heat must be applied in such a manner as to establish this essential condition of the iron.

After pointing out the importance of having a uniform degree of heat throughout the process of carbonizing, the author states that he discovered that by close observation the operator may know almost to a certainty, practically from the beginning of a case-hardening heat, what the final results will be.

It is further claimed that for this purpose no special equipment is needed but only a fair knowledge of heat colors and a proper familarity with the fundamental principles of the case-hardening process. The method developed is based on optical observations made by the writer, which consisted merely of keeping a close watch on the boxes from the time they were put into the furnace cold until they were thoroughly heated or until the color of the boxes blended into the color of the heating chamber of the furnace and noting the manner in which the heat colors displayed themselves over the boxes. From the results of these observations it is claimed that the first show of heat color displayed upon a case-hardening box will indicate without fail the regularity or irregularity of the results of the operation.

In presenting his paper before the American Steel Treaters' Society the author used colored plates which are reproduced in

single color in the paper from which this abstract is made. This limits the ability of describing the color observations of the writer.

In this connection even the original article does not help very much because all illustrations therein are made in black prints. The original paper presented before the American Steel Treaters Society was accompanied by colored plates.

From what he says, it appears, however, that irregularities in coloring of the boxes may be taken as portents of irregularities and results of carbonization, and contrasts of colors tell a story of variations both of penetration and of carbon content which is not told either by physical or chemical tests.

The writer claims that this new method of observation in case-hardening, namely, by colors, opens up a new field for investigation. One of the factors which may be cleared up by such an investigation is the occurrence of inequalities of penetration due to unequal temperatures. Variations of carbon content, however, also affect the amount of penetration. Indeed, it is claimed that in the tests made by the author facts were observed which give a strong impression of possibilities of great variations of carbon existing in the test pieces.

Further, the author emphasizes the fact that the heat diffusion in case-hardening operations does not take place at a uniform rate, because of the different conductivities of the materials through which the heat has to flow. Because of this it is highly desirable to avoid all possible obstacles to uniform diffusion of heat and for the material to be treated as near as practicable to the point of heat generation, which means preheating the case-hardening boxes.

The author secured an even and uniform pentration of carbon content throughout on a batch of several hundred bars of mild steel 8 ft. long. The closed muffle type of furnace was used and 20 bars were handled in each operation, the weight of each charge being more than 950 lb. These bars were placed in the muffle already heated to 1500 deg. fahr. and were held in position until they were uniformly heated to about 1250 deg. fahr. The compound was then introduced and the holding devices removed. The temperature dropped about 200 deg. but rapidly regained an equilibrium between the steel and the compound and in two and one-half hours was at the carbonizing point.

For this purpose the closed-muffle furnace is necessary, but boxes may be used with only slight changes. By a closed-muffle furnace the author means one which can be closed and sealed airtight and so constructed that it may be evenly heated all over. Since the muffle is sealed airtight there is no necessity for covers on the boxes. When the operation of preheating is completed the boxes are removed, covers placed on them if desired, and they are handled just as in the old method. (*Journal of the American Steel Treaters' Society*, vol. 1, no. 3, December, 1918, pp. 87-89, 11 figs., *ptA*)

Advantages of Slow Cooling in Annealing Bronze Castings

HEAT-TREATING BRONZE CASTINGS, G. F. Comstock. Discussion of the effects of annealing bronze-alloy castings and data of experiments made by the author.

The writer describes an experiment in which six tensile-test bars were cast from the same crucible in the same manner. One bar was tested as cast without heat treatment and three bars were heated slowly in an electric muffle furnace to 700 deg. cent. and held there for 30 min. Then one bar was quenched in water, one was taken out and allowed to cool in the air and one was left to cool in the furnace.

This made four bars. The fifth bar was heated to 800 deg. cent. held in the furnace for 30 min. and cooled slowly in the furnace to 600 deg. cent. Then the remaining bar was put in and its temperature maintained at 600 deg. cent. for 30 min., after which both of these bars were allowed to cool slowly in the furnace.

The bars were then tested for yield point, tensile strength, elongation, reduction of area, and hardness, and the results obtained appear to show that annealing at about 700 deg. cent. benefits the alloy, while quenching in water spoils it. (The metal contained 88.5 per cent copper, 9.5 per cent tin and 2 per cent zinc.) In general, however, heat-treated bars show practically no change in yield point or hardness as compared with the untreated bar, while the other properties, especially elongation, were decidedly improved by annealing. (This result is, however, made somewhat doubtful by the fact that the untreated bar had a small flaw.)

An attempt was made to explain by the use of a microscope the failure of the bar quenched in water which proved to be extremely weak in every test, but its structure appeared to be no different from that of the other bars. It seems likely, therefore, that this alloy simply cannot stand the strains produced by sudden cooling in water from a red heat, which makes impractical the idea of trying a double heat treatment consisting of quenching and tempering on copper-tin alloys.

TABLE 1 PHYSICAL TESTS OF BARS WITH AND WITHOUT HEAT-TREATMENT

Bar heated to (deg. cent.)	Cooled in	Yield point, lb. per sq. in.	Tensile strength lb. per sq. in.	Elongation, per cent	Reduction of area, per cent	Hardness Number	Remarks
Not heated	.....	22,100	43,400	26.5	23.7	67	(a)
700	Water	18,200	18,700	7.5	6.7	66	(b)
700	Air	21,600	44,600	41.5	33.5	67	.....
700	Furnace	20,700	45,400	41.5	34.3	68	.....
600	Furnace	21,800	48,500	50.5	46.2	71	.....
800	Furnace	21,000	48,200	58.0	38.0	67	.....

(a) Small flaw. (b) Unsound.

The tests also show that the gun metal or 88-10-2 bronze castings can be improved in strength and especially in ductility by annealing at a red heat or 600 to 800 deg. cent. for at least 30 min., followed by slow cooling. The structural change produced is the removal of the dendrites or soft cores and of the eutectoid or delta constituent resulting in a homogeneous polygonal structure. The same change can be produced by annealing any of the ordinary copper-tin alloys.

As to bronze casting in a chill mold, it is said that it solidifies with great rapidity but the liquid metal heats the chill so much that the rate of cooling below 500 deg. cent. is never fast enough to prevent the better constituent from breaking down into the eutectoid. In other words, the chill prevents the development of great differences in composition between the low-tin dendrites and the high-tin ground mass of the alloy.

Very little is said to be known as to the possibilities for heat-treating of manganese-bronze castings and the writer has therefore made a few experiments along this line.

The effect of quenching manganese bronze in water from a red heat is to fill the metal with invisible cracks which ruin the tensile properties of the alloy. If the best elongation is desired, manganese-bronze castings should cool slowly in their molds and should not be shaken out of the sand hot, unless stiffness is desired rather than ductility.

Interesting data are also presented on the subject of heat treatment of aluminum bronze. (*The Foundry*, vol. 47, no. 321, April 15, 1919, pp. 189-194, 18 figs., *dp*)

HYDRAULIC ENGINEERING

Swiss and French Devices for Automatically Limiting Output of Pressure Piping

AUTOMATIC APPARATUS FOR REGULATING THE OUTPUT OF PRESSURE PIPING, Prof. W. De Schoulepnikow. Pressure piping which connects the starting chambers in hydroelectric plants is often subject to extremely high pressure and to water hammer, which increases the pressure still more. Rupture of such piping is by no means rare and may have grave consequences, as in such cases both the starting chamber and the supply channel

may be emptied and the plant located below runs great danger of being swamped and destroyed. It is therefore absolutely necessary to provide some means to stop the flow in case of rupture of piping.

The simplest method is to put a watchman on the starting chamber and make him responsible for closing the inlet sluice on the piping as soon as an accident becomes in evidence. This method, however, is expensive and not convenient as it is impossible to rely on the constant attention of a watchman.

A better solution is to operate the sluice by means of electric motors receiving their current from the plant. This method, however, likewise requires a certain amount of attention on the part of the plant personnel.

Because of this it appears to be a better plan to employ apparatus which will automatically stop the flow in the piping as soon as it has exceeded a certain amount fixed in advance. Such apparatus may be made to operate either hydraulically or mechanically. Bouchayer and Viallet, engineers in Grenoble, France, have invented a siphoning automatic apparatus which has been employed in the installation at Soulom and the sketch shown in Fig. 7 has been given to the author by the inventors.

The pressure piping *A B C* has the form of a siphon in which the point *B* is above the maximum level *h-h* of the reservoir. The pipe *AI* equipped with the sluice *K* connects the two branches of the siphon and serves to fill up the pressure piping. This latter is also equipped with a snuffle valve *E* connected to the peak of the siphon by the pipe *G*. The priming in the Soulom plant is effected by means of a special water jet, which, at a given moment, aspirates the air from the siphon. The pressure piping is then ready to function.

According to the Bernoulli law, when water flows through the pipe the level in the snuffle valve *E* sinks as the flow of water in the conduit increases. If it goes below the point *F*, air enters, the siphon is deprived of its priming and the flow of water is stopped at once. Because of this, all that is necessary is to determine the height *H* in such a manner as to produce this loss of priming when the velocity has attained a dangerous magnitude, such as would happen, for example, in case of a rupture of the conduit.

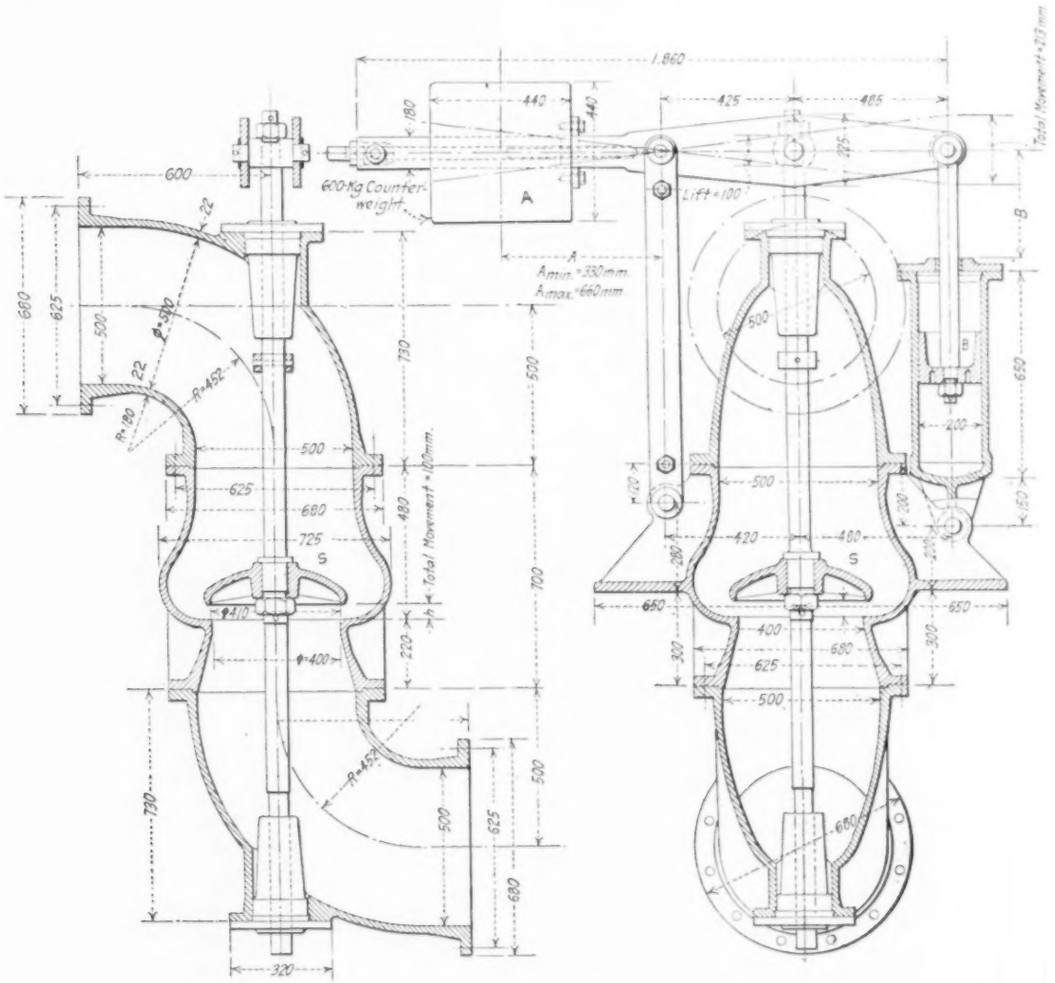

FIG. 6 AUTOMATIC VALVE-CLOSING DEVICE IN THE PIPE AT THE FULLY PLANT, SWITZERLAND

This apparatus requires, however, that the level of water in the starting chamber should not vary too much.

Apparatus in which the stoppage of flow is effected mechanically are free from this rather inconvenient condition, but require a certain amount of attention to maintenance. There are several types of them.

As an example, in Fig. 6 is shown a gate located at the origin of the pressure piping in the Fully plant, which uses the highest head in the world, namely, 1650 m. It is easy to see that the rupture of a pipe working at that pressure would produce a tremendous amount of damage.

The automatic apparatus comprises a valve *S* balanced by an adjustable counterweight *A* which keeps the valve open as long as the velocity of water does not exceed a given value. If this value is exceeded the pressure of the water tends to force the valve against its seat. The hydraulic brake *B* protects the valve against an excessively sudden closure which might break it. Table 2 and Fig. 8 indicate the output for the different values of

TABLE 2 GATE REGULATION FOR VARIOUS RATES OF FLOW

Flow in liters per sec.	Valve Opening		Position of Counterweight
	h	B	
	mm.	mm.	mm.
330	50	350	420
400	50	350	570
440	50	350	660
420	66.7	386	478
470	66.7	386	510
580	66.7	386	545
600	66.7	386	580
630	66.7	386	612
662	66.7	386	660
740	83.3	421	545
775	83.3	421	580
802	83.3	421	612
842	83.3	421	660
888	100	457	545
966	100	457	612
1014	100	457	660

the valve lift h, as well as the position which the counterweight has to occupy for each of these values.

It is believed that this is the first publication of these data ever made. (*Bulletin Technique de la Suisse Romande*, 45 anneé, no. 7, April 5, 1919, pp. 57-58)

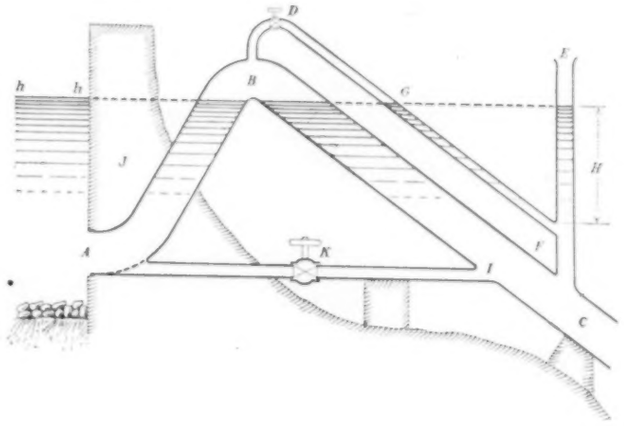

FIG. 7 AUTOMATIC FLOW ARRESTER FOR PRESSURE PIPING IN HYDROELECTRIC PLANTS

INTERNAL-COMBUSTION ENGINEERING

Atmospheric Humidity as It Affects the Output of Internal-Combustion Engines

ATMOSPHERIC HUMIDITY AND THE TESTING OF INTERNAL-COMBUSTION ENGINES, Capt. Ch. Boileau. The writer discusses the question whether atmospheric humidity really affects the output of internal-combustion engines, and if so, how the proper correction shall be made. In the precision testing of engines it is usual to reduce the engine power to a pressure of 760 mm. by multiplying the value actually obtained at a pressure H by $760/H$. Calculation and experiment likewise prove the correctness of this so-called barometric correction.

The second correction (that for temperature) which is always applied in testing gas engines is not as a rule resorted to in testing explosion-type engines with heat-jacketed carburetors. However, with carburetors having no heat jacket such a correction may be necessary, as will be shown later on.

In central and western Europe the atmospheric pressure may easily vary 5 per cent either way, which indicates the amount of error which would be committed if a proper correction were not applied. But there is a third source of error, which, as a rule, is not taken into consideration and the importance of which is equally great. This is the humidity of the atmospheric air. In the present article an attempt is made to show the theoretical basis for such a correction and, as far as possible, evaluate the influence of this factor. An objection may be made to the effect that at the instant of the explosion, phenomena of dissociation occur which it is impossible to measure. This is true; and in the present instance only comparative results may be considered on the assumption that no dissociation occurs.

As regards the method employed in the present instance, it is claimed that it is nothing but a simple application of the usual thermodynamic formulæ—the Zeuner tables for water vapor and the Sorel tables for gasoline vapor. The specific heat at constant volume for superheated water vapor was taken to be 0.55:

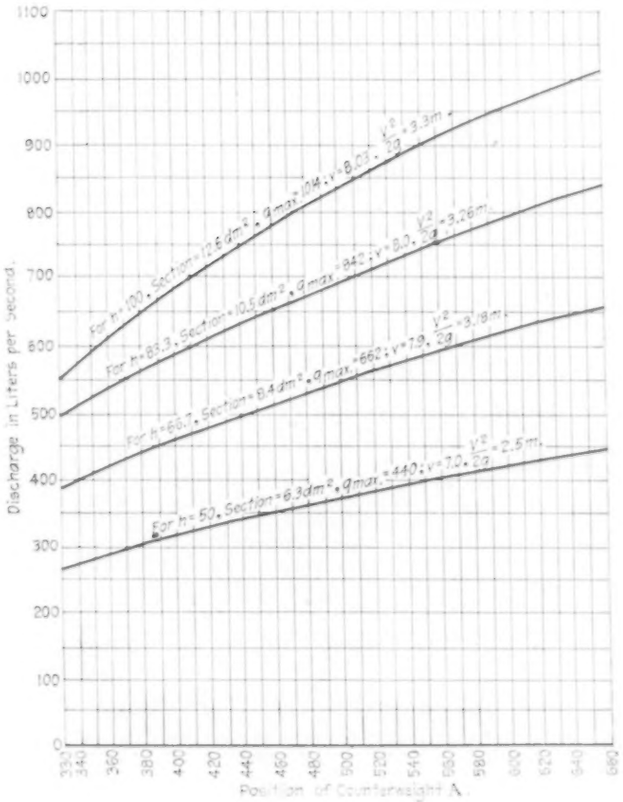
Discharge in Liters per Second.
Position of Counterweight A.
For h=100, Section=12.6 dm², qmax.=1104; v=8.03, V²/2g=3.3m.
For h=83.3, Section=10.5 dm², qmax.=842; v=8.0, V²/2g=3.26m.
For h=66.7, Section=8.4 dm², qmax.=662; v=7.9, V²/2g=3.18m.
For h=50, Section=6.3 dm², qmax.=440; v=7.0, V²/2g=2.5m.

FIG. 8 DIAGRAM OF FLOW AS A FUNCTION OF THE POSITION OF COUNTERWEIGHT IN THE APPARATUS SHOWN IN FIG. 6

1.3 = 0.42 at high temperatures and 0.39 at low temperatures during the period of compression, in calories per kilogram. The following calculation is presented. A swept cylinder volume of 1 cu. m. is assumed with a coefficient of volumetric compression of 4.7, and at first constant atmospheric pressure and temperature (760 mm. and 15 deg. cent.), the only variable being the humidity of the air. Furthermore, since the external pressure does not vary, the same calculations are repeated for different constant temperatures such as 0 deg., 30 deg. cent., etc. Finally, a third variable is introduced, atmospheric pressure, to determine whether its influence is properly taken care of by means of the correction factor $760/H$ when both temperature and hygrometric tension are taken into consideration together.

CONSTANT ATMOSPHERIC PRESSURE

In this connection two cases are considered under the general assumption that the atmospheric pressure is 760 mm. and that the air is first absolutely dry at 15 deg. cent. and next absolutely humid (i.e., saturated) at 30 deg.

CASE 1. $H = 760$, $t = 15$ deg. cent., $f = 0$. The tension of the gasoline at the saturation point and at 15 deg. cent. is equal to 0.304 kg. per sq. mm. The density of gasoline vapor is taken as 3, with air as unity. Hence, in order to saturate 1 cu. m. at that temperature, it is necessary to have

$$1.293 \times 3 \times \frac{0.304}{1.033} \times \frac{273}{288} = 1.083 \text{ kg.}$$

The tension of the gasoline vapor will be given if we assume that the carburetor has an exhaust regulation at 1/20 and is expressed by the equation

$$1.293 \times \frac{273}{288}\left(1 - \frac{x}{1.033}\right) = 20 \times \frac{1.083}{0.304}\, x$$

whence

$$x = 0.017 \text{ kg. per sq. cm.}$$

and the weight of the air is then

$$1.293 \times \frac{1.033 - x}{1.033} \times \frac{273}{288} = 1.203 \text{ kg.}$$

and hence the weight of the gasoline is 60.15 grams.

Compression. For the mixture $pv^{1.33} = \text{Constant}$, and hence $p = 7.75$ kg. per sq. cm., and $t = 187$ deg. cent.

Explosion. The amount of heat produced by explosion is 661.65 cal. The air necessary is $15.1 \times 0.06015 = 0.908$ kg. and the excess air is therefore 0.295 kg., hence

$$661.65 = (T - 460)\left\{[0.06015\ (3.091 \times 155 + 11.62 \times 0.174) + 0.295 \times 0.17] + 0.42 \times 0.0849\right\}$$

from which

$$\tau = 3293, \text{ and pressure} = 55.43 \text{ kg. per sq. cm.}$$

The work of one cycle is equal to the difference between the work of expansion and the work of compression, where both are evaluated by the formula

$$\tau = \frac{\gamma - 1}{p_1 v}\left(1 - \frac{1}{\left(\frac{p_1}{p_2}\right)^{\frac{\gamma - 1}{\gamma}}}\right)$$

whence $\tau = 58.6v$

The author uses conventionally 58.6 to express the value of this factor.

CASE 2. $H = 760$, $t = 30$ deg. cent., $f = 100$ per cent, $F = 0.043$ kg. per sq. cm. The tension of gasoline at saturation equals 0.403 kg. per sq. cm.; the weight of the water equals 30.15 grams, the weight of air equals 1.115 kg.

Gasoline to the amount of 55.75 grams is injected and the whole brought to 760 mm. pressure and 15 deg. cent. temperature by means of the heat jacket. Calculation shows that 1 cu. m. of the mixture contains

1.190 kg. of air
0.0596 kg. of gasoline
0.0128 kg. of water vapor and
0.0194 kg. of entrained condensed water.

Compression. First the writer considers the behavior of a cubic meter of dry steam. If it be treated as superheated steam, a final pressure of 0.132 kg. and a temperature of 202 deg. cent. are obtained.

Under the assumption that 19.4 grams of water are gradually evaporated with the change in compression, it is found that the final state will be the same as if this amount of water were injected into the volume of superheated steam maintained at 0.132 kg. pressure and 202 deg. cent. temperature. This final state is computed from the ordinary equation of mixtures, bearing in mind that if x grams have been evaporated then $(12.8 + x)$ grams of vapor saturate exactly 212.8 liters at that temperature.

From the tables it is found that the final state is then $t = 44.25$ deg., whence $v = 16.13$ and $x = 0.37$ grams, or

$$0.39\ (202 - 44.24) \times 0.0128 = (44.25 - 15)\ 0.0194 \times 0.00037 \times 575.6$$

On the other hand, the mixture of air and gasoline passes at the temperature of 187 deg. and the pressure of 7.62 kg. These two equal volumes of carburated air and wet steam are now mixed. According to the tables 212.8 liters are saturated by 33.2 grams of water at 63.1 deg., which corresponds to a tension of 0.237 kg. per sq. cm. The heat lost by the gas in cooling to t deg. will then serve to raise the internal heat of 13.17 grams of water vapor from 44.25 deg. to 63.1 deg., and to superheat it from 63.1 deg to t deg.; also to raise 19.03 grams of liquid from 44.25 to 63.1 deg. and to vaporize and superheat it to the same temperature of t deg., whence $t = 117$ deg.

In fact

$$(187 - 117)\ (1.190 \times 0.170 + 0.0596 \times 0.35) = 0.06585 + 0.39 \times 0.01317\ (117 - 63.1) + (63.1 - 44.25) \times 0.01903 + 0.01903 \times 562.3 + (117 - 63.1)\ 0.39 \times 0.01903.$$

The pressure of the vapor equals $0.237 \times (390/336.1) = 0.275$ and this pressure is equal to $7.62 \times (390/460) + 0.275 = 6.74$ kg.

The exponent of the polytropic transformation is given by $6.74 = 4.7\ x \times 1.033$, where $x = 1.21$ and the work of compression as determined by the above formula is 9.34.

Explosion. By similar reasoning the theoretical pressure is found to be 52.61. The work according to the same conventions is then represented by

$$52.61 \times \frac{0.381}{0.31} - 9.34 = 55.2$$

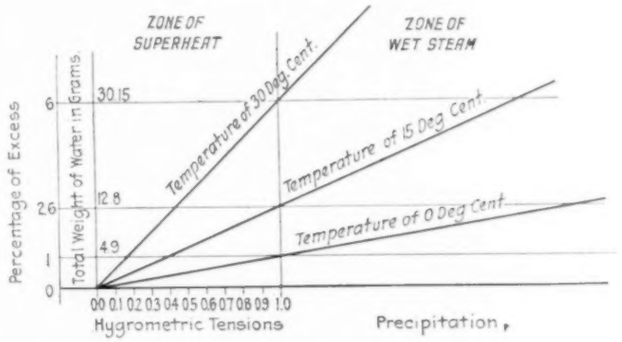

FIG. 9 NOMOGRAPHIC CURVE OF CORRECTIONS FOR AIR HUMIDITY

instead of 58.6, which was the value found for 15 deg. cent. and absolute dryness in the first case.

DISCUSSION OF RESULTS

The foregoing shows the method adopted, which is applicable for every case.

In Case 1 it is found, as might have been expected, that at absolute dryness and any temperature whatsoever the work performed is the same in all cases, which is due to the fact that the carburetor is supposed to bring the gas to a temperature of 15 deg. always and to maintain the gasoline content in the mixture constant.

With constant humidity the work as calculated diminishes with increase of temperature. That is why the values found at 0 and 30 deg. and absolute humidity (saturation) are respectively 58 and 55.2. Therefore, it would be necessary to multiply the value obtained for power output in the test by a coefficient which might vary from 1.01 to 1.06. This indicates that the error from this source is by no means negligible.

For the same temperature the increase in power output is materially proportional to hygrometric tension and, therefore, the law of correction may be quite simply represented by a nomographic curve such as shown in Fig. 9. There the hygrometric tensions are indicated as abscissæ and the percentage by which the power read off the instruments should be increased as ordinates. The corresponding points for the same temperature are found to be located along straight lines passing through the region. On the other hand, care should be taken that the hygrometric state of the air does not go below 0.30. It may be admitted that the average state of the air is about 0.65 and it is

more practical to refer the constants for a motor to this average state rather than to the state of absolute dryness. A simple transformation of Fig. 1 shows that then the coefficient of correction may vary from 0.975 to 1.025. The extreme deviations with reference to operation under the average hygrometric state (0.65) are less important, namely, 2.5 per cent either way instead of 6 per cent in excess of the reading. Nevertheless in acceptance tests their value remains quite important.

Saturation with Precipitation

If the air sucked in by the motor contains droplets of water in suspension, the presence of this liquid should be taken into consideration. The problem is then treated in the same manner as the second case above referred to from the moment of an appearance of condensation.

If the corresponding points for the same quantity of water (vapor or water of condensation) contained in the air are calculated, it is found that the coefficient of correction is essentially the same no matter what may be the temperature under consideration. Hence, if the corresponding straight lines in Fig. 9 for each temperature be extended beyond the abscissæ for 100 per cent, the points corresponding to the same total quantity of water will be found to be essentially on the same ordinate, which may be graduated in percentages of increase of magnitude of power output or in units of water. The values already calculated make it possible to determine the scale of graduation without much trouble. It is found as a matter of fact that within the limits considered the power output should be increased by approximately 1 per cent for each 5 grams of water contained in 1 cu. m. of air.

Variable Atmospheric Pressure

If the foregoing calculations are carried through with a pressure H other than 760 mm. it is found that the results obtained under the same conditions of temperature and hygrometric tension are materially in the ratio of $H/760$. This is particularly so in one of the most unfavorable cases, say, 30 deg. cent. temperature and saturation, since then the water tension 0.043 is of material importance as compared with the atmospheric pressure; still the two coefficients calculated for $H = 760$ and $H' = 0.9$ do not differ from each other except by fractions of one per cent. The barometric correction must therefore be applied in addition to the combined temperature hygrometric correction.

Specific Fuel Consumption

The calculations indicated above give all the elements necessary for evaluating the various specific fuel consumptions. It is found that air humidity has only a very slight influence on the specific fuel consumption and affects it under the most unfavorable conditions to the extent of barely 2.5 per cent. It would appear, therefore, that in practice the increase of specific fuel consumption due to humidity of air falls within the range of errors of reading, of indicating instruments, and of such other errors which are generally covered by the tolerance in determination of experimental results.

All the above results apply to the case of carburetors capable of regulating the temperature of the gas so that it will remain at 15 deg. cent. and of maintaining the mixture in the ratio of gasoline to air of 1 to 20, which is the case with all modern carburetors.

As a matter of fact, however, the preheating never carries the gas to 15 per cent at the instant of admission. This temperature has been selected only as a basis, because it permits the operation of suction carburetors, but it is *a priori* evident that power is gained by maintaining the feed at the lowest possible temperature, or rather would have been gained if there were no danger of condensation of fuel or even congelation of atmospheric vapor as happens all the time with injection carburetors regulated by needle valves in winter.

A computation with zero temperature and dry air will show for τ a value of 61.7 instead of 58.6 under the assumed standard conditions, or a gain of more than 5 per cent.

Because of this, designers do not try to push preheating beyond a few degrees above zero. There is no difficulty in remaking the above calculations, for example, on the basis of heating the gas to 5 deg. and coming still closer to actual conditions by introducing a suitable coefficient of throttling.

Comparative results will be approximately the same, as might have been seen from the start—the effects of lesser heat and reduced admission compensating each other.

Engines with Forced Water Injection

There is no contradiction between the results that have been indicated and those actually obtained on engines with forced water injection, such as the Capitaine-Banki type. All the above considerations had reference to an engine with a normal volumetric compression equal to 4.7. In the Banki motor the volumetric compression went as high as 9.82 and the amount of water injected at full load was 4.84 times the weight of the gasoline, while in the example considered earlier (with the temperature of 30 deg. cent.) the weight of water was only 0.53 times that of gasoline, or one-ninth of that in the Banki motor.

A brief calculation applying the above-discussed principles to the Banki motor is given in the original article. (*La Technique Moderne*, vol. 10, no. 6, June, 1918, pp. 266-269, 1 fig., *e*)

MACHINE ELEMENTS

Sykes Flexible Reversible Coupling. Description with illustration of a flexible coupling made by a British concern. Broadly, it is constructed after the fashion of a crab coupling, one half being provided with pockets, the number of which is determined by the size and duty of the coupling. This portion is keyed on to the half-flange coupling on the shaft, the pockets being designed as in a crab coupling, to receive the radially disposed tenons on the other member, which is keyed on to the motor shaft. Flexibility is obtained by the insertion of rubber blocks, a coupling being assembled so that the rubber is under compression. Hence, as the driving block is further compressed, the idle block expands and prevents backlash.

Provision for longitudinal expansion is accomplished by not pushing the tenon portion right home in the pocket when assembling, but allowing a space between it and the inner face of the pocket.

Slight tilting in the event of the shafts getting out of alignment has been allowed for by forming an annular concave recess on the inner face of the half-flange coupling, so that while the rubber blocks allow slight tilting to take place, the recess permits the end of the tenon portion to accommodate itself to the new position.

It is claimed that such an arrangement is superior to the ordinary spring coupling, because in the latter the flexibility depends upon the springs which must be designed either for the maximum load or for average load. In the first place they possess relatively no flexibility at light load, and in the second place they become practically a solid coupling at heavy loads. The use of rubber provides a degree of latitude in flexibility claimed to be impossible with springs, while its elastic qualities enable it to readily absorb shocks from impulsive loads. (*The Iron and Coal Trades Review*, vol. 98, no. 2667, April 11, 1919, pp. 437, 2 figs., *d*)

MECHANICS

Investigation of Rigidly Connected Reinforced-Concrete Frames

Analyses and Tests of Rigidly Connected Reinforced-Concrete Frames, Mikishi Abe. Discussion of the mechanics of rigidly connected frames and formulæ for moments and other indeterminate quantities for several types of indeterminate structures derived by a method involving the use of the prin-

ciple of least work; also data of tests on frames designed according to the formulæ found by the analyses. The paper is far too extensive to be suitable for abstracting and only the conclusions and general comments of the author are here reproduced.

1 Considering the errors involved in the measurement of the deformations and in the determination of the modulus of elasticity of the concrete, as well as those due to assumptions with reference to the distribution of stresses across the section and over the gage length, the results presented indicate a fair agreement between analyses and tests and justify the conclusion that the formulæ given in the bulletin for statically indeterminate stresses as applied to reinforced-concrete structures will give values for stresses in the members well within the limit of accuracy required in design.

2 The elastic action of the frames under external load and the manner of stress distribution along the members of the frame agree fairly well with the analyses given.

3 The location of the point of inflection in the members of the frames under load agrees closely with the location found by analyses.

4 If a frame is carefully designed and well reinforced, there need be no anxiety as to the rigidity of a joint. Effective continuity of members has been found in the tests.

5 No sudden failure took place in the frames tested. The increase in the deflection was uniform, indicating as great reliability for reinforced-concrete frames as for steel structures.

6 The load at which the first fine crack appears near the juncture of members is increased by fixing the lower column ends of a frame. This is obviously due to the increase in horizontal thrust at the lower column end over that developed when the lower end is free to turn.

7 At sharp inside corners, high compressive stresses were developed in the concrete due to so-called curved-beam action and in several cases local failure occurred by the crushing of the concrete at these corners under high loads.

8 A slight deviation of the axis of vertical members from a vertical line, that is to say, a slight "out-of-form" of the vertical columns, produced an appreciable variation in the stress distribution in the frame.

9 Owing to the existence of a horizontal thrust (which varies from $P/8$ to $P/18$ in most common cases of simple frames) at the ends of a vertical or inclined member, it is advisable to incline the member slightly toward the direction of the reaction at the end. Such arrangement will greatly reduce the bending stress in the member. If this arrangement is not practicable, a slight increase in the top width of a vertical member and a slight decrease in its bottom width, brought about by inclining the inner surface and making the outer surface vertical will add materially to the rigidity of a frame without a proportional increase in the amount of material used.

10 For a frame having an inclined column, it may be possible to select the form of frame in such a way that the column will take no bending stress throughout its length.

11 Due attention should be paid to the rigid joint of a tie member to insure the stiff connection with a main member. A marked tendency to cause a sudden breaking of such a joint was found to accompany an increase of bending moment in the main member.

12 The use of a footing rigidly connected to the lower end of a vertical member is advisable, for it will reduce the bending moment at the juncture of the vertical and inclined members. A frame having such a footing is solvable analytically, since it approaches the case halfway between that of the hinged end and that of the fixed end of the vertical member, provided the foundation is sufficiently unyielding. A little consideration is needed to provide proper reinforcement at the juncture of the column and the footing.

13 The formulæ derived by analysis may be applied to a variety of forms of frames and are of wide applicability. (*Bulletin No.* 107 *of the Engineering Experiment Station, University of Illinois,* 106 pp., 59 figs. and 16 tables, *pe*A)

POWER GENERATION

INTERCONNECTION AS MEANS TO REDUCE NECESSARY STEAM RESERVES, L. J. Moore. Article based on experiences in central California where important benefits have been realized by tying together various power systems.

One of the important advantages obtained by the interconnection of neighboring transmission systems operating hydroelectric plants with steam reserves is the reduction of steam reserve necessary to maintain reliable service.

This is brought about in two ways: (1) by the improvement of diversity factor due to connecting together of dissimilar groups of load; and (2) by the pooling of water resources.

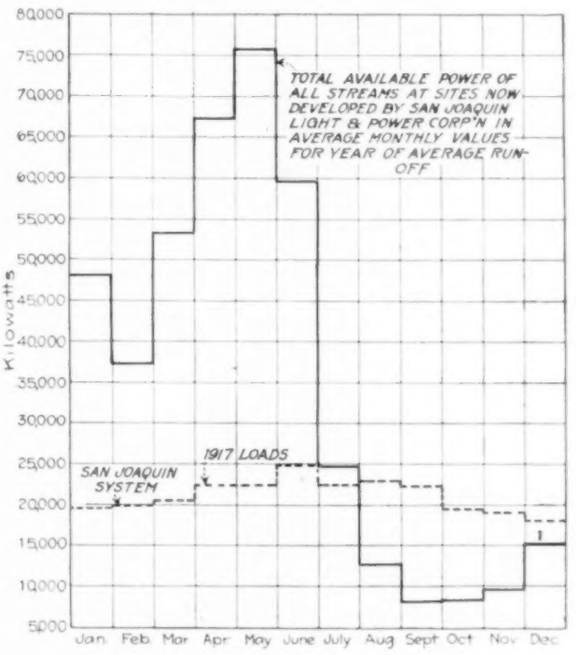

FIG. 10 CURVES SHOWING THE NECESSITY FOR WATER STORAGE FOR STEAM RESERVE IN THE SAN JOAQUIN VALLEY, SOUTHERN CALIFORNIA

The interconnection of three power and light systems operating in the central and southern districts of California is described and discussed in the present article. One of these systems is provided with a 45,000-acre-ft. reservoir for water storage, and two steam reserve plants (one 12,000 kw. and the other 2000 kw.). The second system has a water-storage reservoir of 88,000-acre-ft. and a big steam reserve plant. The third system has no water-storage facilities, but does have a 5000-kw. steam plant.

In addition, one of the companies operates at 50 cycles and the other two at 60 cycles.

The necessity for water storage or steam reserve for hydroelectric plants operating in this region is shown in the curve in Fig. 10 applying to one of the systems. This curve shows the heavy flow in spring and early summer when the plants cannot utilize all the power and the low discharge during the late summer and fall which makes it necessary for plants on this system to be supported by either storage or steam reserve unless they are utilized simply as minimum flow plants.

The flatter curve shows the load on the system for the year 1917 and makes evident the effect of the water-storage reservoir which made it possible to carry the entire load by water.

The article describes in some detail the conditions prevailing in the district and the manner in which the interconnection was effected. Because of this interconnection some of the plants at flood times are run at full capacity, permitting the other parts of the systems to increase their water-storage facilities.

Interconnection of systems operating at different frequencies made frequency changes necessary. Typical results on August 10, 1918, before the installation of the frequency changer, are shown in Fig. 11. The two lower curves show the Edison delivery to the San Joaquin system (the entire Kern River No. 1 plant was running at 60 cycles at the time) and the Mount Whitney demand at Strathmore. The separation of these two curves measures the amount of power the San Joaquin system was absorbing or delivering. These values added algebraically to the load of the San Joaquin system, had no interconnection existed, give the actual power delivered by the San Joaquin plants. The effect on diversity factor in direction of flow of power at Strathmore are evident. This flow has been controlled somewhat on the day shown by variation of the load on the Visalia steam plant, but the fact remains that in practice often one system may be delivering power to the other at a time of light load for itself and peak load for the other, when within a very short space of time the conditions may be completely reversed. This means that they help each other over peaks without the excessive use of steam necessary if they were all operating separately.

The Edison company realizes a saving in delivering power to the Mount Whitney in this way and preventing operation of the Visalia steam plant even at the expense of operating the Long Beach or Redondo steam plant, on account of the much greater efficiency of these two plants. It even pays to let San Joaquin's Bakersfield plant supply the difference, for the reason that Bakersfield is both more efficient than Visalia and because the plant is situated near the oil fields. Delivery of oil to the fire room is much less expensive, and besides a large quantity of natural gas is burned. A gas pipe line connects the Bakersfield plant directly with the oil fields.

The operation of the interconnected system on July 20, 1918, is indicated by Fig. 12, which represents conditions just before low water had raised the Mount Whitney demand and decreased the Edison delivery; as a result a considerable quantity of power was delivered to the San Joaquin company.

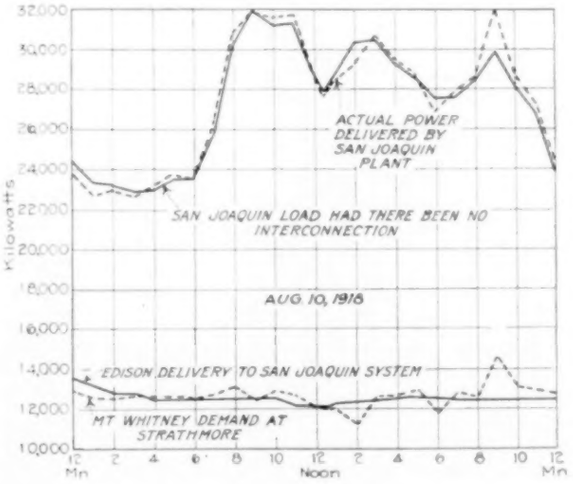
ACTUAL POWER DELIVERED BY SAN JOAQUIN PLANT
SAN JOAQUIN LOAD HAD THERE BEEN NO INTERCONNECTION
AUG. 10, 1918
EDISON DELIVERY TO SAN JOAQUIN SYSTEM
MT. WHITNEY DEMAND AT STRATHMORE
Kilowatts
Noon

FIG. 11 TYPICAL RESULTS ON THE SOUTHERN CALIFORNIA SYSTEM BEFORE INSTALLATION OF FREQUENCY CHANGERS

When one of the 50-cycle impulse wheels at Kern River No. 1 is operating at 60 cycles it is found that the water necessary to generate 5000 kw. at 50 cycles generates only about 4500 kw. at the higher speed. Furthermore, the field current is only approximately two-thirds of normal under this condition. The San Joaquin's prime mover on Kern River is a turbine instead of an impulse wheel, but it gives somewhat analogous results in that a slightly higher output is obtained with the same water when operating on the Edison 50-cycle system. The field current is proportionately higher, too. No particular difficulties are experienced. In fact, the operation is quite satisfactory. (*Electrical World*, vol. 73, no. 17, April 26, 1919, pp. 840-842, 4 figs., *d*)

POWER PLANTS

HIGH-PRESSURE STEEL ECONOMIZERS AT KANSAS CITY. The conditions of boiler operation of the present day lead to increasingly high flue-gas temperatures and great weight of gases passed in a unit time interval. These conditions are very favorable to

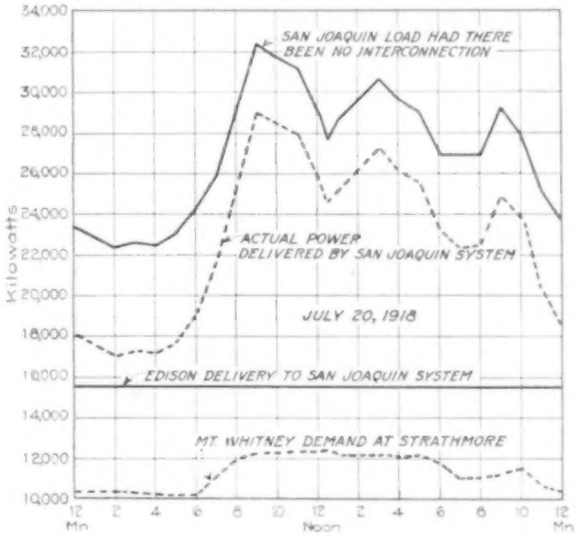
SAN JOAQUIN LOAD HAD THERE BEEN NO INTERCONNECTION
ACTUAL POWER DELIVERED BY SAN JOAQUIN SYSTEM
JULY 20, 1918
EDISON DELIVERY TO SAN JOAQUIN SYSTEM
MT. WHITNEY DEMAND AT STRATHMORE
Kilowatts
Noon

FIG. 12 CONDITIONS AFTER INTERCONNECTION BUT JUST BEFORE LOW WATER HAD RAISED MT. WHITNEY DEMAND

the employment of economizers especially with large boilers. On the other hand, they raise the question of proper materials to be used for economizers.

Cast iron has given efficient and safe service for pressures now common, but it is uncertain whether it will do for pressures of 300 lb. or more. Steel which would be safe for these pressures is, however, not so durable as cast iron, and condensation of the vapors in the flue gas on the relatively cold tubes results in rapid corrosion, especially if the cold steel is high in sulphur. Nevertheless, steel will have to be used if boiler pressures go up still higher and, for example, at around 1000 lb. cast iron would be entirely out of the question.

In the new power station now being erected for the Kansas City Light and Power Company this problem has been met by dividing the economizer into two sections, a high-pressure and a low-pressure section.

The low-pressure section (cold part) of the economizer is of cast iron while the hotter part, which is the high-pressure section, is of steel construction something like a section of a Stirling boiler.

The feedwater has to be pumped first through the low-pressure economizer into a tank which forms a suction tank for the boiler-feed pumps by which it will be pumped through the high-pressure economizer and into the boiler. The economizers are so proportioned that the water is to be heated in the low-pressure economizer to a temperature not over 200 deg. fahr., which will prevent the formation of steam in the low-pressure economizer and at the same time put the water into the high-pressure economizer at a temperature sufficiently high to prevent any condensation there. In this way the condensation and consequent corrosion is confined to the low-pressure sections where leakage and deterioration are much more easily controlled.

The high-pressure economizer is made up of two 36-in. drums, 23 ft. long, having 306 3¼-in. cold-drawn seamless tubes ¼ in. thick, arranged in 38 sections of 8 tubes each, front to back.

Each high-pressure economizer contains 4205 sq. ft. of heating surface and, moreover, is so baffled that the gases are compelled to pass over the tubes transversely three times. It is supported from the building steelwork, the support being at the upper end so as to be free to expand downward. The economizer is inclined 35 deg.

Each low-pressure cast-iron economizer, of the Green type, has 336 12-ft. tubes, 7 tubes per header, with a total of 5500 sq. ft. of heating surface. Each economizer is 16 ft. 11 in. long and the outside overall width is 16 ft. 2 in. The induced fans, one for each boiler unit, are of the multivane type, with two single inlets, driven by one 150-hp. slip-ring induction motor. Each boiler and economizer is intended to evaporate 80,000 to 100,000 lb. per water per hour, going up to 120,000 lb. per hour when forced. (*Power*, vol. 49, no. 15, April 15, 1919, pp. 556-557, 1 fig., *d*)

PUMPS

Submersible Motor-Driven Pumps for Salvage Work

SUBMERSIBLE SALVAGE PUMPS AND ENGINES. Description of a type of pump extensively employed of late by the Salvage Section of the British Admiralty and, as far as known, not previously described in full.

This machine consists of a centrifugal pump directly connected to an electric motor, so designed that it is capable of indefinitely operating while submerged in water.

It frequently occurs in the earlier stages of salvage operations that if powerful pumps can be brought to work immediately, there is a good chance of success, but a short delay may mean total loss or, at best, a much greater expenditure of time and money. In such cases the time required for rigging steam or oil-driven pumps is too great while a salvage vessel carrying submersible electric pumps can run alongside the wreck and in a very short time have the pumps working with current supplied from dynamos on board. This has in fact been done on several occasions by Admiralty salvage vessels. The S. S. *Westmoreland*, worth over £2,500,000, was salvaged in this way under circumstances in which no other kind of pump could have been employed.

The submersible electric pumps when at work are usually suspended by a rope from a derrick, or any other convenient part of the wreck, and will work in any position. One of these pumps was recently put to work on a vessel which had capsized, and continued to work at its maximum output while the vessel was being righted to an angle of 90 deg.

When the compartment in which it was situated was unsealed, the pump was found to be upside down and to have rolled to quite a different position to that in which it was placed.

Since it is not always convenient to supply current from a salvage vessel, an oil-engine-driven dynamo had to be developed which would be waterproof and unaffected by water conditions. This is especially important for use in tidal waters where the engine may have to remain in position while the tide rises and completely submerges the plant. An engine type has been developed which is capable of being covered with water without coming to any harm. The engine cannot, of course, work while submerged.

The means adopted to permit the engine to withstand submergence in water are very simple, but required a large amount of experimentation in working out.

The foremost characteristic is that the engines have a very plain outline. Every possible part of the mechanism is arranged inside the trunk or crankcase, and those parts which protrude are of very robust construction. In order to prevent water from getting into the interior of the engine all the openings such as the inlet and exhaust are provided with easily attachable covers and the crankshaft where it emerges from the crankcase passes through a stuffing box. The gland of this stuffing box is left slack when the engine is running and only screwed up in the event of probable submergence. In a test after a submergence of 24 hours only about two pints of water had found their way into the crankcase while the electrical fittings were unaffected. The whole of the ignition gear (both magneto and battery) is enclosed in a gun-metal case with a good-fitting cover.

Two types of this engine are now built; one with two cylinders of 12 b.hp., and the other with four cylinders giving from 45 to 50 hp.

The oiling system in these engines is of the same general type as that used in the Allen high-speed steam engines, that is to say, oil is pumped into a duct cast in the bedplate and led up through the hollow pedestals to the main bearings. Thence, some of it finds its way through holes drilled in the crankshaft to the crankpins and big ends, while the hollow connecting rods take the supply up to the gudgeon pins.

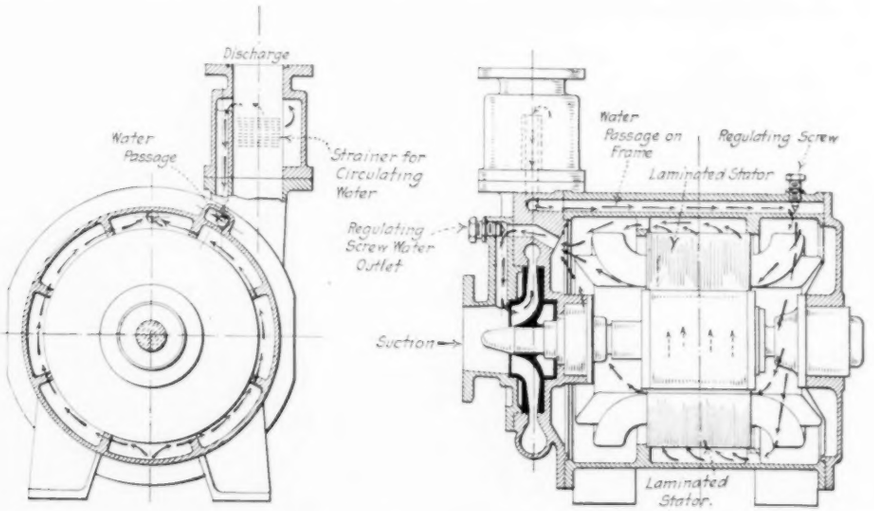

FIG. 13 SECTIONS THROUGH SUBMERSIBLE PUMP AND MOTOR USED BY THE SALVAGE SECTION OF THE BRITISH ADMIRALTY

The construction of the motor has been generally known for some time. The water is actually encouraged to enter for the purpose of cooling the machine and the windings are protected by the simple expedient of making them from one piece of heavily rubber-covered wire. Because of the ample cooling made possible by admitting the water, rubber insulation becomes permissible and this is the only waterproof material that seems to meet the requirements. The squirrel-cage type has been adopted, as it makes electrical connections with the rotating parts unnecessary.

The pump itself is of the usual single-inlet pattern with a gun-metal impeller. The 4-in. pumps are capable of delivering

100 tons of water per hour against the head of 75 ft. and require 17 kva. The largest set built is 18 in. and is capable of raising 1750 tons per hr. to a height of 30 ft. Fig. 13 gives a section through the pump and motor. Unfortunately the illustrations showing the engines are not suitable for reproduction. (*The Engineer*, vol. 127, no. 3299, March 21, 1919, pp. 274-276, illustrations on page 278, 9 figs., *d*)

RAILROAD ENGINEERING

WATER TREATMENT ON THE GREAT NORTHERN RAILROAD, C. Herschel Koyl. East of the Rocky Mountains the Great Northern crosses a strip of country 600 to 700 miles wide where the water not only contains a considerable amount of mineral matter but is also very irregular in its composition, being sometimes alkaline and sometimes hard; and during the past six years it has been developing a system of water treating adapted to its special purposes.

The methods developed have now given water satisfactory for its content of sodium sulphate over a strip of 1100 miles.

The character of the chemical treatment of the water varies with the character of the water, but all cases are covered by the use in proper proportion of hydrated lime, soda ash (sodium monocarbonate) and sulphate of iron (ferrous sulphate).

The purpose of using hydrated lime is to neutralize carbon dioxide. Soda ash is used to replace the scale-making lime sulphate by a non-scaling medium sulphate, while ferrous sulphate is used in the first place for the treatment of the last grains of calcium carbonate so that it will not clog the injector pipe; second, for the conversion of caustic sodium hydrate into neutral sodium sulphate; and third, for the further weighing and more rapid settling of particles of light suspended matter. Treatment with ferrous sulphate is stated to be a device introduced by the author for the first time in this connection.

Important advantages are claimed to have been secured by the use of water treatment. Not only has foaming disappeared, but with freedom from leaks boiler operation became far more reliable. In this way a large amount of time was saved on the road, not merely because boilers did not leak and fail but also because the service became more dependable, and in this way speeding up of each department has been made possible.

The following illustration of what water treatment has done is given in a report from the master mechanic of one of the districts. Engines on a certain section used untreated water and a set of flues never lasted longer than six months. Since water treatment has been introduced the scale has all come off from stays, crown bolts and flues, and with the aid of a little kerosene the flues and sheets have been kept as clean as on the day the engine came out of the shop, notwithstanding the fact that it has been in service under the new conditions for 15 months.

On the other hand, no attempt has been made to reduce boiler washing, because on account of the concentration of sodium sulphate and sludge in the mud ring, the boilers are washed every round trip, same as before the water treatment was introduced.

Other important advantages are mentioned in the original article and a water-treating plant briefly illustrated. (*Railway Age*, vol. 66, no. 17, April 25, 1919, pp. 1053-1056, 1 fig., *d*)

VARIA

FRACTURE OF TWO COMPRESSED-GAS CYLINDERS AND THE CAUSE (*Zeitschrift des Vereines deutscher Ingenieure*, March 8, 1919). The present writer made a most complete investigation into the cause of fracture of two compressed-gas cylinders—one for hydrogen and the other for oxygen—which burst while in course of filling.

The hydrogen cylinder was being filled with the gas at a pressure of 140 atmos. The explosion was extremely violent; the floor on which the cylinder was standing was found to have a hole in it 75 cm. deep; the flask or cylinder flew upward like a projectile, passed through the roof of the filling room, and fell in a garden some 85 m. distant.

An examination of the plant (compressor and fittings) revealed it to be in order.

The gas was produced electrolytically and collected in a gasholder, after which it passed into a two-stage compressor and was compressed to a filling pressure of 150 atmos.

A full chemical, mechanical and micrographic examination was made of the fractured cylinder, from which the writer concludes that it satisfied the requirements of the authorities. Probably a "fold" or crease formed in the steel while being mechanically treated, and this creasing gave rise to a crack or cracks, which were most likely the cause of the explosion.

He suggests that in addition to the prescribed precautions relating to the inspection of these vessels, each seamless vessel should be "flash-tested" (this test is not defined) before the head is put on, in order to find faulty places. This method has been adopted by the military authorities prior to the acceptance of all shells. This test would enable any creases to be discovered in the steel.

In the case of the oxygen cylinder a greater number of splinters were available.

The cylinder is said to have burst during the process of filling at a pressure of 80 to 100 atmos. The oxygen used was obtained from liquid air.

The cylinder was of similar construction to the hydrogen cylinder, being of the seamless-steel type. The same official regulations applied in this case also.

The article describes in detail the mechanical, chemical, etc., tests carried out on the fragments collected.

Numerous causes contributed to the bursting of the cylinder as shown by the experimental results.

The steel was weakened at one particular part where the test initials were stamped, as the stamp penetrated to half the wall thickness of the cylinder.

The steel was too brittle for the purpose in question. It was very sensitive to dynamic stresses.

The author suggests that the regulation regarding the stamping of these cylinders should be modified. The stamping should be reduced to a minimum, and be done when the steel is in a red-hot state.

A mere pressure test is, when employed alone, very defective. It is much more important to test the inside and outside surfaces and the thickness of wall of each cylinder prior to putting on the top.

Complete tables, illustrations, etc., accompany the above paper. (*Technical Supplement to the Review of the Foreign Press*, vol. 3, no. 9, April 29, 1919, p. 311, no. 4910).

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

The following statement of the National Advisory Committee for Aeronautics shows the development in airplanes which has been made since 1903. The first man-carrying airplane flights were made in December, 1903, with the Wright Bros. engine, developing 12 hp. and weighing 152 lb., or 12.7 lb. per hp. In 1910, the average horsepower for aeronautic engines had increased to 54, and the weight had decreased to 5.7 lb. per hp. After another 7 years, in 1917, the average power output had advanced to 243 hp., and the weight had decreased to 2.8 lb. per hp. In March, 1918, the Liberty motor developed 432 hp. for a weight of 808 lb., or 1.86 lb. per hp. At present, the Liberty motor is developing a maximum of 450 hp. for a weight of 825 lb., or 1.83 lb. per hp. The average consumption of fuel decreased from about 0.8 lb. per hp. in 1903 to 0.55 lb. in 1918, and for the Liberty engine to 0.50 lb. The present consumption is about 0.46 lb. per hr. (*Machinery*, p. 744, April 1919)

MECHANICAL ENGINEERING

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

It is proposed to publish in MECHANICAL ENGINEERING for July a complete account of the Detroit Meeting. Inasmuch as the meeting does not end until June 19, the day before the usual closing date for the journal, the publication of the July number will necessarily be delayed several days. The volume of work entailed in reporting a convention is very large, involving as it does the summarizing of perhaps 600 pages of stenographer's notes, besides handling the written discussion; but it is hoped that it may not be necessary for the July number to be more than one week late in reaching its subscribers.

Major Fred J. Miller Joins the A. S. M. E. Staff as Consultant

Major Fred J. Miller has joined the staff of the Society in the capacity of consulting engineer and advisor upon its publications. In this he will coöperate with the Papers and Publication Committee in the development of MECHANICAL ENGINEERING, which has made notable progress during the past year through the acquirement of The Engineering Index and the addition of other features of direct benefit to the practicing engineer.

Major Miller has served on the Council of the Society and on various committees and has been intimately acquainted with its activities over a period of many years. He was one of the earliest to advocate the establishment of the Society's journal, at first known as the Proceedings, and it is fitting that he should now be able to render additional service to the publication in which he has long taken so deep an interest.

For ten years he was editor-in-chief of the *American Machinist*, which reached a high plane of technical journalism under his direction and to which he personally made notable contributions that attracted wide attention. Following this he became Factory Manager of the Remington Typewriter Company. Shortly after the United States declared war against Germany he entered the service and organized and directed the Civilian Service Division at the Rock Island Arsenal. Later he went to the Office of the Director of Arsenals at Washington, when, at the request of the War Labor Board, he was detailed to the Bethlehem Steel Works. He has recently resigned from the service and is now in consulting practice. The Society is to be congratulated upon having at this time of progressive development the benefit of his sound judgment and long experience in publication and organization work.

The Spring Meeting

ON the opposite page is given tentatively the complete program for the Spring Meeting of the Society to be held at Detroit, Mich., June 16 to 19. The papers for the meeting are being published progressively in MECHANICAL ENGINEERING, the first appearing in the April number, and practically the whole of the technical section of this issue is given up to these papers.

Unusual interest attaches to the opening of the meeting on Monday because of the progress report to be presented by the large and representative Committee on Aims and Organization which has long been in preparation. On Tuesday morning there will be what is perhaps the most important, or keynote, session, on the subject of Research in Engineering, under the direction of the very active Research Committee of the Society. In view of the marked development in research work throughout the country and the recent reorganization of the National Research Council to promote and coördinate research, this session ought to have the attention of all the members in attendance. Several timely papers are to be presented, together with reports by three of the Sub-Committees on Research.

In the afternoon of Tuesday there will be a general session of non-technical character, such as is provided at each convention, for discussion of administration topics according to the current developments in the field of industry. The general theme will be Industrial Relations, with addresses bearing on the needs of the time for securing industrial peace and the recent movement toward greater representation on the part of employees in the conduct of the affairs of industrial firms.

Several papers on Wednesday morning, as well as at other sessions, are contributed by the Mid-West Sections, these constituting some of the best contributions offered for the meeting. They are indicative of the prominent place which the Sections have attained in the affairs of the Society and of the substantial assistance which they are rendering in building up the Society's publications through their contributed articles.

There will be one session under the auspices of the Gas Power Sub-Committee, a General Session for miscellaneous technical papers, and on Thursday morning a closing session very pertinent to the power-plant situation at the present time, for the discussion of fuels. There will be three papers on pulverized and crushed coal and one on oil fuel. In view of the fact that low-grade fuels are necessarily assuming a more important place in power-plant operation, and also that power-plant efficiency through the development of the steam turbine and improvements in steam boilers permits the use of high-pressure and superheated steam, the next step forward appears to be in the boiler furnace. Under these conditions the possibilities of fuel in finely divided or pulverized form becomes an absorbing subject for discussion.

The Detroit Local Committee has drawn on the wonderful resources of the city of Detroit for the entertainment of their guests and, as outlined in the program, there will be numerous excursions to industrial plants of very great interest. An afternoon and evening will be spent on the Lake and dinner served on the excursion boat. There will be an evening of music and dancing at Arena Gardens, and the Ladies Committee has arranged various entertainments for the visiting ladies, including motor trips, etc.

Records of War Service

It is intended to publish an account of service rendered by members of the Society in the World War.

To that end it is requested that every member of the A. S. M. E. who served in the Army or Navy, or who in any other way rendered direct service to the Government during the war, send to the committee a full account of his service. Address Committee on War Service, care of the Society.

SPRING MEETING PROGRAM

Detroit, Mich., June 16-19. Headquarters, Hotel Statler

Monday, June 16

10:00 a. m. Opening of headquarters and registration at Hotel Statler

10:00 a. m. Council Meeting

2:00 p. m. Business Meeting followed by Report of Committee on Aims and Organization

8:30 p. m. Address of Welcome by Mayor James Couzens. Reception and Dance. Refreshments

Tuesday, June 17

10:00 a. m. Professional Session

Research Session

(Under auspices of Research Committee)

The Present Condition of Research in the United States, Arthur M. Greene, Jr.
Research Work on Malleable Iron, Enrique Touceda
Reports of Sub-Committees on Flow Meters, Bearing Metals and Lubrication
The Organization and Conduct of an Industrial Laboratory, A. D. Little and H. E. Howe.

10:30 a. m. Trip to Burroughs Adding Machine Company. Luncheon at plant

12:30 p. m. Luncheon at Hotel Statler for Council and Sections Representatives

2:00 p. m. Professional Session

Industrial Relations Session

Industrial Personnel Relations, ArthurM. Young (contributed by the Chicago Section)
The Status of Industrial Relations, L. P. Alford
Certain Aspects of the Management Problem, Magnus W. Alexander

(Other speakers to be announced)

2:30 p. m. Trip to Morgan and Wright Company's Plant

8:30 p. m. Musical entertainment, Arena Gardens, 1253 Woodward Avenue. Dancing, Cards, Refreshments

Wednesday, June 18

10:00 a. m. Simultaneous Sessions

Sections Session

(Under auspices of Sections of Mid-West)

Central-Station Heating in Detroit, J. H. Walker (contributed by Detroit Section)
Production of Liberty Motor Parts at the Ford Plant, W. F. Verner (contributed by Detroit Section)
Fire Engines and the Essentials of Fire Fighting, C. H. Fox (contributed by Cincinnati Section)
Electrical Method for Measuring the Flow of Fluids in Pipes, J. M. Spitzglass (contributed by Chicago Section)

Gas Power Session

(Under auspices of Sub-Committee on Gas Power)

Crude-Oil Motors vs. Steam Engines in Marine Practice, J. W. Morton

(Other papers to be announced)

10:00 a. m. Trip to Connors Creek Plant of the Detroit Edison Company. Luncheon at plant

2:30 p. m. Steamboat trip through St. Clair Flats. Steamer Britannia leaves foot of Bates Street, returning at midnight. Dinner on boat. Entertainment, dancing, refreshments.

Thursday, June 19

10:00 a. m. Simultaneous Sessions

Fuel Session

Pulverized Coal as a Fuel, N. C. Harrison
Economy of Certain Arizona Steam-Electric Power Plants Using Oil Fuel, C. R. Weymouth
Pulverized Coal for Stationary Boilers, H. G. Barnhurst and Frederick A. Scheffler

General Session

Elements of a General Theory of Wing Design, Walter C. Durfee
Air Fans for Driving Electric Generators on Airplanes, Capt. G. Francis Gray, Lieut. John W. Reed and P. N. Elderkin
Mechan'cal Lifts, Past and Present, and a New Method for Their Balancing, Lieut. J. F. Robbins
General Equations for the Design of Riveted Butt Joints, A. A. Adler
The Economical Section of a Water Conduit, Cary T. Hutchinson (By title only)

Morning left open for special trips. Members are requested to indicate, upon arrival at headquarters on Monday, which plants they desire to visit.

2:00 p. m. Trip to Ford Motor Company, Highland Park

The Crossing

ON May 26, 1819, an American ship, the *Savannah*, was tne first steam-driven vessel to cross the ocean. One hundred years later, on May 17, 1919, an American seaplane fully commissioned as a ship in the United States Navy crossed from Trepassey Bay, Newfoundland, to Horta, on the Island of Fayal, Azores, making port in 15 hr. 18 min. after leaving ground at Newfoundland. (This is as far as the flight has progressed at the time of going to press.)

There are several elements in this flight worthy of the most careful consideration by engineers.

The ship was of the heavy-load-carrying type with its full water-landing equipment and wireless. Furthermore, it was of the multi-motor type, this also materially increasing its weight. The fact that a seaplane of this type could make a flight of over 1200 miles without forced landing, in record time for a craft of its weight, is a strong proof both of the high state of the development of aeronautical engineering generally and of the advance made in particular by the American Navy.

The working of an aeroplane, and in particular of the aeroplane engine, has been correctly compared to that of a racing car. Every part of the engine and plane is at full load under high stresses and moreover the aeroplane is in some respects in a less fortunate position than a racing car, because it is more subject to vibrations and does not have the damping protection of the road under the tires.

Because of this, there is a far greater tendency toward fatigue in both the engine and frame of the plane. A car that could make 1200 miles at the rate of 85 miles per hour without stoppage for adjustments and without engine or frame trouble would have been a very remarkable car, indeed, and yet the Navy seaplanes have done it.

This performance is also a proof that the Liberty engine, with which the seaplanes have been driven, has passed through the period of development and may now be considered as a fully completed product entitled to the highest consideration for its reliability of performance and economy in fuel consumption.

The American Navy has been famous for its proverbial luck. The flight from Trepassey to Fayal Island gives a little insight into the secret of Navy's "luck." Such a flight would have been impossible without the most careful preparation and in fact it would be no exaggeration to say that, roughly, the performance of May 17 is a direct outcome of work of close upon two years.

It would have been impossible unless everything had been prepared in such a manner as to work close to an efficiency of 100 per cent. The failure of a small part in the plane, of a few spark plugs in the engine, of some connecting rod, or valve push rod might have marred or made impossible the crossing, and the fact that the crossing has been achieved shows that everything from the large factors to the smallest details must have been approximately 100 per cent perfect.

Transatlantic passenger transportation will not follow right on the heels of the crossing by the Navy seaplanes. In fact, if anything, this flight has shown not only that it is possible to cross the Atlantic in the air but also that it is by no means easy to do so. Notwithstanding the elaborate precautions taken for guiding the fliers, the NC 1 and NC 3 lost their bearings in a dense fog and even the NC 4, which completed the flight, stopped at Horta instead of Ponta Delgada, the spot designated for landing. The NC 3, after being "lost" for two days, was discovered on May 19 only seven miles from the harbor of Ponta Delgada, proceeding under her own power, but the NC 1, after being located and taken in tow by a destroyer, was later wrecked through heavy seas.

Spurred on, doubtless, by the departure of the Navy squadron, Harry G. Hawker, the famous Australian aviator, made on May 18 his daring plunge from Newfoundland for the British Isles in the Sopwith biplane. Entirely unprotected against a fall at sea, and even without protection against a dangerous alighting upon the land in order to reduce the weight of his machine, he took the hazardous risk—and failed.

Nevertheless, in spite of the tremendous difficulties to be overcome, a start has been made in the air voyages across the Atlantic.

Thirteenth Engineers Return to Chicago

The Thirteenth Railway Engineers recruited from the six railroads which center in Chicago were given a most royal welcome upon their return to that city on May 12. Approximately 10,000 people are reported to have lined Michigan Boulevard to witness the parade, which was reviewed by Major General Black, Chief of Engineers; Colonel R. D. Black, general staff, and one of the organizers of the Thirteenth Engineers; S. M. Felton, president of the Chicago Great Western; and W. L. Park, federal manager of the Chicago Great Western, and chairman of the reception committee. Major General Leonard Wood was also to have reviewed the regiment but was caught in the crowd at one of the street crossings and was unable to pass. The parade started at 11.30 with Colonel C. L. Whiting in command. As the men marched along Michigan Boulevard the engineers on the Illinois Central and other railroads opened their whistles and the resulting din silenced the famous band of the regiment. Following the parade the men were dined and entertained and later entrained for Camp Grant where they will shortly be demobilized.

The Thirteenth Regiment was largely an operating unit and during the greater part of their stay overseas were engaged in transporting troops and munitions in the Argonne and St. Mihiel sectors. The regiment is credited with having moved 103 trains of men and munitions during a period of only 24 hr. They also operated the trains which carried the famous 14-in. Navy guns.

Past-President Henry R. Towne Reaches a Business Anniversary

A souvenir booklet of historic value has been issued by the Yale and Towne Manufacturing Company, of which Henry R. Towne, Past-President, Am.Soc.M.E., was one of the founders. It is issued as a Semi-Centennial Souvenir of the company, and contains, besides a history of the works, an account of the various men who have contributed to its upbuilding and various other data and information concerning the organization, products, war activities, etc., of the company.

The birthplace of the Yale industry was at Newport, Herkimer County, New York, where, about 1840, Linus Yale, Sr., began the manufacture of "pin-tumbler" locks. His son, Linus Yale, Jr., a talented and ingenious inventor of locks, formed a partnership with Henry R. Towne, which resulted, in October, 1868, in the organization at Stamford, Conn., of what is now The Yale and Towne Manufacturing Company. Mr. Towne undertook the manufacturing management of the company. The corporation was organized in 1868, with Mr. Yale as president, but upon the latter's death, a month later, Mr. Towne succeeded as chief executive and president, and continued in that position until his resignation as president in 1915 to accept the chairmanship of the Board.

The products of the Yale firm, just prior to the formation of the partnership with Mr. Towne, were bank locks, seven varieties of key locks, and the metallic post-office lock box, the employees numbering about 35. The present daily output is 25,000 locks, with an organization under normal conditions of 3000 men.

Westinghouse Scholarships as War Monuments

E. M. Herr, president Westinghouse Electric & Mfg. Co., Pittsburgh, has announced the establishment of four technical scholarships by his company to commemorate the part played during the war by its employees. Selection of the candidates will be determined by annual competitive examination conducted by the company's educational department under the direction of a committee consisting of three vice-presidents, who will also prepare the regulations and all details of administration. Each scholarship carries with it an annual payment of $500, and the student may take any course of engineering at whatever school he selects having the approval of the committee. Scholarships are for one year only, but will be continued for four full years provided the student maintains the standards required by the institution he has elected to attend. The number of new scholarships will be four each year. (*Iron Age*, May 8, 1919.)

Aims and Organization Committee

A COMMUNICATION on Standardization of Aims has been prepared by James Hartness, Past-President, Am.Soc.M.E., and member at large of the Aims and Organization Committee of the Society, for the consideration of the Sub-Committee on Relations of the Mechanical Engineer to His Work. From this communication the following extract has been taken which is of interest to those who are giving thought to present conditions and the general trend of events:

One of the points that I wish to emphasize is the importance of having an aim that fits the world's best ideals—an aim that will disarm all destructive isms.

We must aim to make the high special knowledge and experience of the engineering profession of value in guiding all the individual activities along lines of highest beneficial results to all people. We must select a slogan that everyone can understand, one that would put to shame any disruptive activity on the part of advocates of sham scientific or sham economic doctrines. We have reached a point where something more than argument and logic must be served out to the American people.

The war has started the functioning of something we call the heart, and this something, which for convenience we call the inner man, is a thing that dominates, is a thing that may be swayed by noble purposes or it may be stampeded into mob action. While educational institutions are instructing the brains, Bolshevism is stampeding the inner man. The lines of communication between the average highly trained engineer and the great mass of workers are absolutely down. For instance, the engineer thinks that he can direct mechanical and industrial activities by specifications and drawings issued from some central office. The workers know that specifications miles long and diagrams that would cover the whole continent cannot give sufficient direction to enable him to skillfully perform certain operations. We know the ship cannot be rigged and the industry cannot be economically and successfully operated without special skill and ability in each of the jobs, from the highest skilled down to the lay president's job.

In view of this, engineers who insist on disturbing the workers by office type of management should be looked upon as drags and menaces, and The American Society of Mechanical Engineers should make for its chief slogan "FITNESS FOR SERVICE," with the interpretation of fitness that includes enthusiasm, optimism, good will, noble purpose, integrity, appreciation of the other fellow, readiness to pay in honor and tribute as well as cash, and to admit, to begin with, that the real people in this world are those who are rendering an effective service in an essential work.

The inner man is now deeply stirred throughout our whole land, and if we go on and talk of refinements of organization; if we go on drawing diagrams, showing the relative position of each officer; if we go on issuing tabulations of dimensions in three- or four-place decimals of the inch relative to the sizes of rubber bands and screws when not under tension, we will be living in a fool's paradise. It is one that is sorely threatened at the present time, and there should be an awakening even of the so-called highly cultured people that will match and help to head off the stampede of those who are doing things with their hands.

When we get the right slogan: "Fitness for Service," the administration of our railroads, of our coal distribution, and in fact every other part of our glorious republic will be properly handled. Then, the affairs of this great industrial country will be handled by men competent to manage such things; committees for investigating industries will be composed of men with practical industrial knowledge and experience; political preferment will pass away.

Then the influence of the speculator in Wall Street will vanish, and the men of Wall Street will stay where the war has put many of them—in positions in which they are rendering essential service; men who have been struggling for special laurels of wealth will be struggling to attain the higher laurels of real value, the new and true standard of greatest service and greatest fitness for service. Then we will realize the vision of Washington, Lincoln and of the true leaders who are being born out of the travails of war. Then the activities of the country will no longer be handicapped by unwise guidance of labor.

The American Society of Mechanical Engineers must have such a slogan or it will gradually become farther and farther removed from the head of the procession. There is nothing so deadening to an organization as to lay behind general progress. It leads to indifference, to pride, and to all those things that are distinct menaces, and that is what The American Society of Mechanical Engineers is up against at the present time. We point to our growth in power and numbers and forget that we have a thousand times our present power and should lead the whole world in administrative as well as constructive achievement.

[The report of the Committee on Aims and Organization has now been drafted and will be presented at its meeting in connection with the Spring Meeting on Monday, June 16, at Detroit, Michigan, at 10 a. m. The Council is expected to receive the report and to order it transmitted to the semi-annual business meeting at 2 p. m. on the same day, where it will be thrown open for discussion by the membership. To prepare the field for this discussion a preliminary draft of the report has been referred to the members of the Committee for them to discuss with the Sections they represent and to this end several Sections have already arranged special meetings.—EDITOR.]

Spokane Engineers Want to Meet You

Mr. A. D. Butler, Secretary, Spokane (Wash.) Engineering and Technical Association, has sent a note to the Secretary saying it is the desire of his association to come in contact with engineers who may be going to that section of the country, or passing through Spokane. There is a meeting of some one of the committees of the association nearly every day in the week, and it would afford them much pleasure to have at luncheon any engineers who are in touch with important matters, at which time a gathering would be arranged to talk over the engineering field in general. Spokane engineers desire to keep well informed on problems in the different parts of the United States and to broaden their field of acquaintanceship.

Government to Give Motor Trucks to States

Twenty thousand motor trucks valued at more than $45,000,000 are about to be distributed by the Secretary of Agriculture through the Bureau of Public Roads to the state highway departments. These trucks have been declared surplus by the War Department and will be distributed to the states under the provisions of Section 7 of the Post Office Appropriation Bill. They must be used by the states on roads constructed, carried on in whole or in part by Federal aid. All that the states need do to acquire the use of these 20,000 trucks, which range in capacity from 2 to 5 tons, is to pay the loading and freight charges. Of the trucks to be thus given to the states 11,000 are new. All, however, are declared to be in serviceable condition. They will be apportioned to states only upon request of the state highway departments on the basis of the requests received from the respective states, and in accordance with the apportionment provided in the Federal aid law approved in 1916.

Three-Cylinder 60,000-kw. Turbine Installation

The largest turbo-generator and the first three-cylinder unit in the United States was placed in service on October 9, 1918, at the 74th Street station of the Interborough Rapid Transit Company of New York City. The new unit consists of one high-pressure turbine and two low-pressure turbines, each directly connected to a generator. When in normal operation all three elements are electrically connected. The turbines run at a speed of 1500 r.p.m., and each generator will deliver at that speed 20,000 kw. at 25 cycles (3-phase) and 11,000 volts. The new unit thus has a maximum continuous rating of 60,000 kw. It is also capable of carrying a load of 70,000 kw. for two hours. It occupies a floor space of 50 by 52 ft. When operating with a load of 40,000 kw., which is the most economical load, steam is supplied to the high-pressure element at 211 lb. per sq. in. abs. and a temperature of 250 deg. fahr. This is exhausted into the low-pressure turbines at a pressure of 29.7 lb. per sq. in. abs. and a temperature of 250 deg. fahr., and in the low-pressure elements the steam is further expanded to the pressure in the condenser (1 in. mercury abs. and 79 deg. fahr.).

The electrical features of the installation are of the most modern type. Each generator is protected by reactance coils and a relay system. Should a burnout occur in the windings of any generator, this relay system will at once disconnect it from the line. In addition to the usual governing mechanisms there has also been provided an arrangement whereby any turbine can be operated should the others, for any reason, be taken out of service. For example, if it becomes necessary to shut down the high-pressure element, each low-pressure turbine will automatically receive high-pressure steam. On the other hand, if both low-pressure elements are removed from service, then the high-pressure turbine will automatically exhaust to the atmosphere, but if only one low-pressure turbine has been removed, then the one remaining will still continue to receive high-pressure steam.

Since it is also necessary to control the three turbines when they are operated independently, each turbine is provided with a governor, which will immediately cut off the supply of steam if the speed exceeds a predetermined value. There is also provided between the high-pressure and low-pressure turbines a butterfly valve which will automatically close should the speed of the low-pressure turbine become excessive. In a similar manner, if the high-pressure turbines speed becomes excessive, then a governor will cut off steam to the entire system, and when the speed reaches a lower fixed value the governors of the low-pressure turbine will operate and admit steam directly to them. (*Electrical World*, May 10, 1919, pp. 933-935)

Advances in Automatic Control in Hydroelectric Plants

In the West, during the period of war stress, many helpful economies in power development were brought about that must inevitably be felt in the industrial life of the nation for many years to come. Not only was the production of fuel oil increased, but the generation and utilization of electric power both from water resources and from fuel supply was vastly forwarded. In some instances the task involved the establishment of new records in magnitude of engineering attainment such as the interconnected systems of long-distance power lines which have not been even approached in length of transmission or magnitude of distribution anywhere else in the world.

But perhaps the advances that have been made in automatic control will ultimately prove of even more lasting benefit to the industry in lessening labor costs, and hence in decreasing the cost of power production, than any other single cause.

The one-man cars for street railways, the automatic control of substations, such, for instance, as the new installation from Salt Lake City to Saltair in Utah, and the automatic control of power house generators as installed quite recently by the San Joaquin Light & Power Corporation, are forceful instances of this recent trend in economic design.

The Crane Valley power house of the San Joaquin Light & Power Corporation is of unusual interest. Here it is estimated that an average of over three million and one-half kilowatt-hours will be saved by taking advantage of power not hitherto used in the rise and fall of the lake level of Crane Valley Reservoir.

The unusual feature of variable head, ranging from 120 feet down to 80 feet, has been successfully overcome. This power house, in addition to a second installation below, is operated without attendants, and only the regular dam tender and reservoir tender make visits to the plant from time to time. An alarm system is installed in the caretaker's cottage so that he is notified if the machine is tripped off the line. The machine, in the meantime, may attain runaway speed. However, should the machine trip off the line and increase in speed, a centrifugal switch on the shaft of the unit closes a circuit on the wicket gate, operating a motor, which closes the wickets and shuts down the machine. The water in the ditch immediately starts to rise, and flows over the weir by-pass until such time as the caretaker of the plant arrives and puts the machine back on the line.

The recent advances in automatic control witnessed on all sides, combined with the irresistible trend toward outdoor switches and transformer stations, augur well for increased economic power generation and lend a certain hope to the power situation that is pleasing to contemplate. (*Journal of Electricity*, April 15, 1919)

U. S. Trade Commissioner

Secretary Redfield has appointed Alexander Luchars, publisher of *Machinery*, New York, United States Trade Commissioner to Great Britain, France, Belgium, Italy, Switzerland, Holland and Scandinavia, to study conditions in those countries affecting our engineering and machinery industries. Mr. Luchars' acquaintance with European manufacturers and engineers, and his connection with similar industries in this country as a publisher, will enable him to render effective service to American manufacturers. Mr. Luchars will spend about four months in Europe.

Production of Liberty Motor Parts at Ford Plant

(*Continued from page 522*)

the burrs on the inside or babbitted surface of the bearings. The fixture was made in halves, the lower half having a cylindrical section which served to hold the fixture in the machine. Ways for the slide carrying the broach were machined in the lower half, and also recesses cut for the hardened and ground blocks on which the parting surfaces of the work rested. The upper half was made in the form of a clamp, this part being bored to fit the half-section of circular hardened and ground steel liner, the inner surface of which fits about the outside of the work. Bosses bored for guide pins extended from the fixture and served to keep the halves in alignment. The weight of the upper half was disposed on springs coiled about the guide pins. The broach was of a semicircular section and bolted to the slide. This slide was connected to the ram of the machine. A copious flow of oil was kept on the work, keeping the locating block and broach free from chips and dirt. The cutting was done on the pull or regular stroke of the machine.

The Status of Industrial Relations

(*Continued from page 516*)

relations controversies. Such matters are justiciable today; they were not twenty years ago. We may look forward to a time when controversies in regard to such rights will become just as justiciable as any controversy in regard to property. It is possible that when this time comes it will be properly referred to as the era of industrial democracy.

Three tendencies in this development of industrial relations seem to be new though they are not novel.

The first is the acceptance of motive of service, which on moral grounds declares for recognition of the rights, needs and aspirations of every one engaged in or dependent upon industry. It is the engineering viewpoint rendered unselfish.

The second is the willingness to consider workers in groups. By training and experience the engineer has only been willing to look upon workers as individuals. Two of the governing principles that have brought modern industry to its present heights are the division of labor which minutely subdivides the job, and the selection and adaptation of the worker which individualizes him and attempts to fit him to some particular task, tool or machine. This is the viewpoint of specialization which deals only with units.

But in industrial relations the workers must be considered in groups or in the mass. This is the viewpoint of the industrial psychologist as contrasted with that of the technical engineer, and the latter has been slow to understand that his methods of subdivision and specialization cannot be used successfully in dealing with the problems of industrial relations. Much has been said about fostering coöperation, but little progress has been made. A reason for this situation is found in the lack of understanding on the part of industrial executives that to build *morale* or the *spirit of the organization* their working people must be appealed to in the mass and not as individuals.

The development of the safety committees began to open the eyes of industrial executives as to what might be accomplished once employees as a body had a chance to express their desires and opinions. The present movement to establish shop committees will carry this experience further and into new aspects of the problems of industrial relations. The experience so gained will show the possibilities and advantages of discarding the individualistic viewpoint of the engineer. It will also bring the passing of arbitrary and autocratic decisions.

The third tendency is toward mutual or joint control, toward mutuality and the working out of representation. It is an expression of democratic ideals.

From the experience of the past and in the face of the tendencies and forces now operating we may confidently expect a greater development in industrial relations during the immediately forthcoming years than in any preceding equal period of time. May engineers accept their entire responsibility and perform fully their duty in working out proper solutions of the problems presented!

ENGINEERING COUNCIL

Engineering Council[1] is an Organization of National Technical Societies of America, Created to Consider Matters of Common Concern to Engineers, as Well as Those of Public Welfare in Which the Profession is Interested

Conference on a National Department of Public Works

IN a recent number of MECHANICAL ENGINEERING announcement was made of the conference on the subject of a National Department of Public Works called by Engineering Council to meet in Chicago April 23 to 25. While in the years before the war a great deal of the engineering and construction work done independently by the different departments of the Government could probably have been accomplished more efficiently and expeditiously if placed under one directing head, the urgent need for such centralization of authority has only come to be generally recognized since the signing of the armistice.

Apart from the military engineering required for the conduct of the war, a vast quantity of civilian engineering was required, aggregating 800 million dollars' worth of hospitals, storehouses, railroads, waterworks, etc., which was carried through by the Construction Division of the Army, the personnel of which included a large number of the best engineers in the country.

The Construction Division's existence is, by law, to terminate 90 days after the signing of peace, and unless the maintenance and operation of these Government facilities, and the disposal of them where they are not to be maintained, are turned over to some board which is familiar with their details and requirements, chaos is sure to result.

It is proposed, therefore, that a Department of Public Works shall be formed, of which the present Construction Division of the Army, under civilian control, shall be a part. Also, that various other of the Government's engineering activities shall be consolidated under this new department for unified control.

The conference at Chicago for the consideration of the project was attended by 71 delegates representing 74 organizations, with a membership of over 100,000; and 7 members of Engineering Council and three members of the National Service Committee of the Council, these latter not as delegates, but with voting privileges. The Chairman of the Conference was M. O. Leighton, Chairman of the National Service Committee, and the Secretary, E. S. Nethercut, Secretary of the Western Society of Engineers, both elected by the conference. J. Parke Channing, Chairman of the Engineering Council, made the introductory speech, giving the purpose of the conference and setting forth the reasons why engineers urge the formation of a National Department of Public Works.

After a general discussion, the main question of the recommendation that such a department be established was referred to a resolutions committee, whose report was adopted as follows:

1 That the services and bureaus of the National Government having to do chiefly with matters of engineering and architecture, be grouped in one department to be known as the Department of Public Works.

2 That the Department of Public Works comprises those works which are built and operated for the use of the Public.

3 That the Department of Public Works be made available when desirable for the performance of special engineering and architectural work for the use of other Government bureaus.

4 That there be a systematic classification and organization of engineers, architects and other employees whose status shall be such that they may be recruited and maintained on merit.

Also, a committee on the scope of a Department of Public Works presented the following report, which was adopted:

1 That the establishment of a National Department of Public Works should be accomplished by grouping those Government bureaus, services, commissions and other activities whose functions are predominantly of an engineering or architectural character, in what is now the Department of the Interior and thereafter designating that department "The Department of Public Works."

2 That the transfer of any bureau, service or commission from any other department to a Department of Public Works should be accomplished without change of personnel, compensation and general plan of organization, leaving the coördination of the several activities, the simplification of organization and the establishment of additional bureaus such for example as a bureau of chemical engineering, to be effected as the need for the same may from time to time become apparent.

3 That in transferring river and harbor work and other work non-military in character, but now in charge of the Engineer Corps of the United States Army, to a Department of Public Works, the relation of the army engineers to such work be not changed and that there should be no relinquishment of non-military duty by the army engineers now on such duty until transfer of these engineers to military duty can be made without detriment to the public interests.

Your Committee finds that among the bureaus, services and activities, which logically belong to a Department of Public Works, are the following:

A Bureau of Public Roads,
The United States Reclamation Service,
The Alaskan Engineering Commission,
The Construction Division of U. S. Army,
A Bureau of River, Harbor and Canal work, including such functions as are now exercised by the Mississippi River Commission and the California Debris Commission,
A Bureau of Architecture,
A Bureau of Surveys, including the Coast and Geodetic Survey,
A Bureau of Mines,
The Geological Survey,
The Forest Service—at least until the same is divorced from the supervision of water powers and road building,
The Bureau of Standards.

Your Committee believes that it would be unwise to determine at this time to what extent the proposed Department of Public Works should control the engineering activities of the General Land Office; of the National Park Service; of the Bureau of Lighthouses; of the Bureau of Indians Affairs, and of the Public Health Service and of various commissions, such as Commissions on buildings and grounds, and therefore suggests that such matters may well be deferred for consideration to a later date, preferably until the Department has been organized.

Following an extended discussion of ways and means for continuing the work of the conference and promoting the passage of a bill in Congress for the establishment of a Department of Public Works, a permanent organization was effected. It was voted that the conference should be designated as the Engineers, Architects and Constructors Conference on National Public Works, and that it continue in existence until dissolved by its own action.

An Executive Committee, a Committee on Text of Bill and a Campaign Committee were appointed.

[1] Officers of Engineering Council: J. Parke Channing, *Chairman;* Alfred D. Flinn, *Secretary*, Engineering Societies Building, 29 West 39th Street, New York.

NATIONAL SERVICE COMMITTEE

Contributed by the Washington Office[1]

Standardization for War Department

A SYSTEMATIC effort is being made in each Division of the War Department to make permanent the meritorious practices which grew out of the strenuous war experience. Because of the realization of the need of standardization there grew the Engineering and Standardization Branch of the Purchase, Storage and Traffic Division under the General Staff. This has shown that by working out standardization in all War Department specifications, savings at the rate of many millions a year can be effected in time of war and very material reductions in expenditures effected even with the army on a peace basis.

There are nine divisions under the General Staff which depend largely on engineering work for their operation—namely, Ordnance, Engineer Corps, Signal Corps, Construction Division, Chemical Warfare, Aircraft Production, Military Aeronautics, Quartermaster and Motor Transport Corps. Formerly each of these divisions had its own specification for each article purchased by the War Department. The electrical catalog, for instance,

[1] Washington Office in charge of M. O. Leighton, *Chairman*, National Service Committee, McLachlen Building, 10th and G Streets.

contains 25,000 items. Through the Engineering and Standardization Branch uniform specifications are being devised so that compact but complete catalogs for each class of commodity can be written up which will cover the requirements of every department. This at once simplifies the matter of specifications and purchases for the War Department, makes it possible for them to order in greater quantities and enables the manufacturer to get out his product and deliver it to the various departments at a maximum of efficiency.

Every effort is being made to accomplish the enormous task in a comprehensive and scientific manner. Authorities from various fields are being called in for consultation and wherever questions of engineering are involved Engineering Council, through its National Service Committee, has been called in to consult.

The organization of the Engineering and Standardization Branch is at present subdivided into research, production, inspection, standardization and catalog sections. The research section for instance, will make such investigations as are necessary to assist in standardization work and will arrange for definite forms of procedure in research work through various departments of the Government so that there will be not only standard methods but also standard departmental routine in which these methods will be followed. The production section will lay out definite schedules for quantity and specialty production, which they will recommend for use in the manufacturing arsenals and to individual manufacturers. The standardization of material will take place along lines that will insure interchangeability of a given article with the same article used in another department.

Information Service for Engineers

THE National Service Committee of Engineering Council announces a National Legislative and Departmental Information Service for Engineers in all branches of the profession. The statistical, research and construction bureaus of the Government have become valuable sources of engineering information, but have not been used by engineers to the extent merited by the character of their material. Many matters before Congress involve engineering consideration, of which members of the profession should be aware. When in need of information from the above sources, or concerning congressional matters, set forth specifically what is wanted and address the National Service Committee, M. O. Leighton, *Chairman*, 502 McLachlen Building, Washington, D. C.

Scientific and Technical Employees of the Government in Washington Organized

STEPS were taken for a permanent organization of the scientific and technical employees of the Government at their mass meeting on May 8, 1919. This was the result of an informal meeting on April 23 of 30 representative Government scientists and technical men who organized the preliminary committee and called the mass meeting. This subject has been widely discussed during the last year and was brought acutely to the fore by the work of the Joint Congressional Reclassification Commission, because that commission has stated that it wished to deal with employees only through organizations.

Rodney H. True of the Department of Agriculture, Acting Chairman, pointed out that the principal advantages to be expected from such an organization were: (1) Improvement of conditions and facilities for more effective scientific and technical work; (2) Adequate presentation of the needs and results of such work to the public and to legislative and administrative officers; (3) Greater freedom in both official and non-official activities; (4) Just and reasonable salaries based on service performed and the economic and social conditions which prevail; (5) Greater public recognition of the aims and purposes of research; (6) Advancement of science and technology as an essential element of national life.

Three plans of organization were offered to the meeting, which covered the fundamental principles which could be utilized by these Government employees. The first plan would have permitted the new organization to work only through existing scientific organizations. This is the plan that scientific and technical government employees in England have adopted and an outline of the English plan was read to the meeting. An independent organization of federal employees doing scientific and technical work was also proposed and a third plan, which was finally adopted by the meeting, provided for the forming of a scientific and technical branch of the Federal Employees' Union. This was upheld principally by Dr. Rosa of the Bureau of Standards. He pointed out the unfavorable conditions under which scientists working for the Government had to solve big problems, and that this, the richest nation, can afford the best scientific service. The present service is fast drifting from efficient channels because of the loss of their best personnel.

His principal reason for recommending the affiliation with the Federal Employees' Union at once was because of the going organization and the prestige that it had already established.

This is an important step forward for the scientific and technical Government employees because it is contemplated that it will lead to important reforms in classification and compensation. It is closely connected with the work that Engineering Council has aimed to accomplish through its committee on Classification and Compensation of Engineers, and it is contemplated that Council will be able to give effective coöperation in the work of classification that must be inaugurated.

Plans for Training of the Commercial Engineer

THE Commissioner of Education has issued a call for a public conference on business training for engineers and engineering training for students of business. This conference, national in scope and character fully representative of all interests, will be held in Washington, D. C., on June 23 and 24.

This conference has been called on behalf of the Conference Committee on Commercial Engineering, which is composed of administrative professors in engineering and commerce from several of the large educational institutions and representatives, from the Society for the Promotion of Engineering Education, the American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers and a Committee of Fifteen on Educational Preparation for Foreign Service. The major topics to be discussed are Business Training for the Engineer; Engineering Training for Commercial Enterprises; Significance of the War Experience for Engineering Education; and Training of the Engineer for Foreign Projects.

Plans for Railroad Control

MANY interesting plans covering the ownership, operation and control of railroads have been shown in Washington. It is always interesting to the engineer to note the position of the various organizations directly connected with this work, because all branches of the profession are intimately related to the vicissitudes of the railroads.

On the one side generally stands labor and on the other side stand all the other interested parties. This is the case with the railroads. The railway executives, railroad security owners, Interstate Commerce Commission, Director General of Railroads and numerous individual financiers and railroad men all stand for private ownership and operation of the railroads because they believe that efficient operation can be had in no other way. The railways brotherhoods on the other hand stand for Government ownership and they want the operation of the roads to be by private corporation, run by employees and paying Government rental out of the receipts of operation.

Government ownership and operatives' management of railroads is summed up in what is known as the "Plumb Plan." Mr. Glenn E. Plumb is attorney for the "Big Four Railroad Brotherhood" and the ten brotherhoods affiliated with the American Con-

federation of Labor. He has just arrived in Washington to care for the interests of this plan. He announced that it is to be incorporated in the form of necessary bills for legislative action which will be introduced at the approaching special session of Congress. Mr. Plumb expects the railroad problem to develop into a presidential campaign issue and contemplates that the railroad question will have to be "put up to the people direct." Mr. Plumb says, "If these demands (for rate decreases) were fully met, any deficiency must be made by wage reduction." His own words perhaps best explained his reason for coming to the national capital.

The brotherhoods' plan for the control of the railroads provides that there will be no "Secretary of Transportation" but there will be continuation of powers of Interstate Commerce Commission. The directors shall be elected, one-third by non-appointed employees, one-third by appointed officers and employees, and one-third by the President.

The railway executives recommend that a cabinet officer, to be known as "Secretary of Transportation," be appointed. They say that the Interstate Commerce Commission should be relieved of the executive and administrative duties, except as to the valuation and accounting, and they are to act as a quasi-judicial body with regional commissions.

Railway security owners recommend federal regulation through the Interstate Commerce Commission, as at present constituted, and coördinating with six regional commissions, who in turn will coördinate with the state officials.

The present Interstate Commerce Commission wants a better defined relationship between state and federal control, with a broadening of federal control.

The Director General, as is commonly known, stands for five-year extension of federal control with modified private operation and control thereafter. This plan provides for Government representation on boards of directors.

NATIONAL RESEARCH COUNCIL

Dr. George E. Hale Resigns as Chairman and Dr. James R. Angell is Appointed as His Successor. New York Office of the Council Opens in the Engineering Societies Building

IN the last number of MECHANICAL ENGINEERING reference was made (p. 485) to the recent organization of the National Research Council of the National Academy of Sciences on a peace-time basis, and to the pioneer work which its distinguished chairman, Dr. George E. Hale, Director of Mt. Wilson Observatory, had done in coördinating and directing its activities.

Announcement has been made that Dr. George E. Hale will hereafter be the Honorary Chairman of the National Research Council and Dr. James R. Angell, ex-president of the University of Chicago Settlement and member of the American Psychological Association, who so eminently served the Nation on the committee of the Adjutant General's office on classification of personnel in the Army and as advisory member of the committee on education and special training, will replace Dr. Hale in the executive direction of the Council.

The chairmen of divisions of the National Research Council have been appointed as follows:

DIVISION OF PHYSICAL SCIENCES. Chairman, C. E. Mendenhall; acting chairman until June 30, A. O. Leuschner.

DIVISION OF ENGINEERING. Chairman, Henry M. Howe; vice-chairman and acting chairman, Galen H. Clevenger.

DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY. Acting chairman until June 30, E. W. Washburn; chairman, July 1, 1919, to June 30, 1920, W. D. Bancroft; vice-chairman, Julius Stieglitz.

DIVISION OF GEOLOGY AND GEOGRAPHY. Vice-chairman and acting chairman, E. B. Mathews.

DIVISION OF BIOLOGY AND AGRICULTURE. Chairman, C. E. McClung; vice-chairman, L. R. Jones.

In these divisions there are representatives of the various leading societies associated in the particular work covered by the divisions. In the Engineering Division the societies represented are the Civil, Mining, Mechanical and Electrical, Illuminating and Automotive Engineers, the Society for Testing Materials and Western Society of Engineers. The representatives from The American Society of Mechanical Engineers are Arthur M. Greene, Jr., Chairman of the Research Committee of the Society, and Past-Presidents W. F. M. Goss and D. S. Jacobus, the two latter being members of the Engineering Foundation.

According to a note in *Science*, May 16, 1919, the National Research Council has announced the following initial appointments to national research fellowships in physics and chemistry:

In Chemistry. F. R. Bichowsky, of Washington, D. C., A.B., Ph.D., physical chemist at the geophysical laboratory of the Carnegie Institute of Washington since 1916; Mr. Bichowsky plans to conduct researches at the University of California. Emmett K. Carver, of New York City, A.B., Ph.D., formerly assistant to the director of the Wolcott Gibbs Memorial Laboratory at Harvard, Captain, Chemical Warfare Service, U. S. A. W. H. Rodebush, Ph.D., present research chemist for the United States Industrial Alcohol Company, of Baltimore, Md.; Mr. Rodebush will conduct researches at the University of California on a Study of the Specific Heats and Other Properties of Substances at Low Temperatures.

In Physics. Leonard B. Loeb, of New York City, B.S., Ph.D., formerly assistant physicist at the Bureau of Standards, Washington, D. C., Lieutenant, Aviation Service, U. S. A.; Mr. Loeb will conduct his researches at the University of Chicago. Robert A. Patterson, of Bristol, Conn., A.B., Ph.D., formerly instructor in physics at Yale University, Major, Field Artillery, U. S. A. George P. Paine, of Madison, Wis., A.B., Ph.D., instructor in engineering mathematics University of Wisconsin; Mr. Paine will conduct research work at Harvard University and at Blue Hill Meteorological Observatory.

Another important development which no doubt will bring about practical results of value to the engineering profession is the recent affiliation of the Engineering Foundation with the National Research Council. To contribute to the mutual collaboration of the two institutions, office space in the Engineering Societies Building has been provided by the Engineering Foundation to serve as the New York Office of the Engineering Division of the National Research Council, and the Foundation, having brought its office to the adjacent room, in addition proffers to the Council and its Engineering Division such secretarial services as the Foundation may from time to time determine.

The office of the Engineering Division of the National Research Council was opened on June 1, and is now operating under the direction of Galen H. Clevenger, acting chairman of the division. The National Research Council proposed that its Engineering Division, comprising in all not less than 23 or more than 28 members, of whom at least 7 and not more than 12 shall be members at large, be so organized as to include at least 5 members of the Engineering Foundation, and, including these 5, 17 members of the Founder Societies; this proposal was accepted by the Engineering Foundation as well calculated to meet the mutual requirements of the Foundation and the Council. It is the purpose of the Engineering Foundation to collaborate with the National Research Council in the activities of its Engineering Division and to make such appropriations to aid its specific undertakings as the Foundation may from time to time determine.

Patents originating in Government service or patents which may be turned over to the Government by private inventors who are not able to develop their inventions commercially are to be administered by the Department of Commerce if the proposed bill for this purpose is passed by the next Congress.

NEWS OF THE ENGINEERING SOCIETIES

Report of Annual Meetings of Electrical Engineers, American Institute of Architects, National Metal Trades Association, United States Chamber of Commerce, etc.

Institute of Radio Engineers

At its meeting of May 7, held in the Engineering Societies Building at New York, the Institute of Radio Engineers presented to Mr. E. F. W. Alexanderson, of the General Electric Company, a gold medal in recognition of his achievements in the field of radio communication. The wireless telephone, declared Mr. Alexanderson in his remarks following the presentation of the medal, was the result of an attempt to transmit power without wires. The possibilities of the wireless telephone having once been conceived, however, experiment and research soon developed it so that today it is an accepted fact.

American Institute of Electrical Engineers

At the annual business meeting of The American Institute of Electrical Engineers, held in New York on May 16, the presentation of the Edison Medal for meritorious achievement in electrical science or electrical engineering took place, it being awarded this year to Benjamin G. Lamme, of the Westinghouse Electric and Manufacturing Company. The presentation was made by William B. Jackson, Vice-President of the Society.

The award was made to Mr. Lamme for inventions and developments of electrical machinery. During the war he served as a member of the Naval Consulting Board, to which he was appointed on the recommendation of the institute. Mr. Lamme has taken out more than a hundred patents for electrical devices, appliances, and systems now in general use.

The society recently held its annual election and announcement was made of the election of Calvert Townley of New York as president and of the reëlection of F. L. Hutchinson as secretary for the administrative year, beginning August 1, 1919. Mr. Townley is assistant to the president of the Westinghouse Electric and Manufacturing Company. He served as an active official of the New York, New Haven and Hartford Railroad in connection with the electrification of the New York terminal zone of that property and is an authority on electrification.

National Machine Tool Builders' Association

The need of continued close attention to production costs and their relation to selling prices and the disposal of the machine tools which the United States Government has on its hands both here and in Europe were the leading topics before the Spring meeting of the National Machine Tool Builders' Association at Atlantic City, May 12-13.

Colonel Guy Hutchinson, assistant director of sales, War Department, expressed appreciation for the part which the machine-tool industry had played in the war. It was production more than man power, the speaker said, that determined the issue of the war. He regretted that production had not got an earlier start, saying that the small quantity of munitions which the United States got to the front before the crucial time arrived had cost a large number of the lives of our allies. The big mistake made, he asserted, consisted of turning factories into playgrounds for engineers for about one year.

The Committee on Safety Codes reported that the Bureau of Standards at Washington was calling for nation-wide regulation of safety provisions, and that two plans had been suggested. Under one of these the Bureau of Standards would draw up general regulations which were then to be adopted by the states, and under the other the work of securing uniformity would be undertaken by the American Engineering Standards Committee made up of members of the national engineering societies.

In his address President A. E. Newton foresaw a keen competition in the near future between manufacturers of machine tools. He warned against what he termed the fallacies of an erroneous study of cost-accounting systems. He advised that in reducing prices it was not sufficient to consult the cost as shown by the individual machines, but also to take into account the real cost as shown by the annual statement. A full report of the meeting is contained in the *Iron Age* for May 15, 1919, from which the foregoing notes were taken.

American Institute of Architects

A prominent feature of the fifty-second annual convention of the American Institute of Architects, held at Nashville, Tenn., April 30, May 1 and 2, was the discussion of the principles set forth in the program of the Post-War Committee on Architectural Practice. The debate on the various topics taken up was a serious and thoughtful consideration of the elements of architectural practice that are now considered of vital significance in the reorganization of the profession. Preliminary to the discussion, John Bell Keeble, member of the bar of the state of Tennessee, spoke on the Relationship of the Professions.

In his address on Professional Principles, President Thomas R. Kimball pointed out the part professionalism should play in developing adequate relations between architects, the public and the other professions. He condemned the practice, as he termed it, among professional men of indulging in tales of discomfiture to and of each other and before audiences inclined to be more interested than discerning, and expressed his belief that through professionalism as a common factor architects may reach an interprofessional understanding based on the common factor of giving skilled service to others.

N. Max Dunning, chairman of the Post-War Committee, stated that in his opinion two important things had been emphasized by our war experience: the value and necessity of organization, and the proper appreciation of the value and nobility of service.

National Foreign Trade Convention

Necessity for an expanded foreign trade in stabilizing domestic conditions was emphasized and the vital factors wherein this country is at a present disadvantage in overseas commerce were set forth by the National Foreign Trade Council in summing up the deliberations of its sixth convention at Chicago, April 24-26, which was dedicated to the theme, Foreign Trade Essential to the American Industry. A forward-looking recommendation was that congressional consideration be given to suitable plans for developing aerial navigation, and it was declared that the promotion of airship service to overseas countries demands the establishment of a separate government department. It was suggested that local chambers of commerce entertain the advisability of having public aerodromes in all centers which expect to develop large foreign markets in order that prompt delivery of plans and specifications, blueprints and invoices may be made from seaports to the interior. Throughout the convention stress was laid upon the fundamental rule that if this country is to have an enlarged export trade it must also be prepared and should expect to receive a greatly expanded volume of imports. Enduring foreign trade, it was stated, must be reciprocated.

National Metal Trades Association

That 86 per cent of the metal-working establishments of the country have a working schedule of 50 or more hours per week,

was brought out at the annual meeting of the National Metal Trades Association, held at New York, April 23-24. Less than 10 per cent of the members of the association have an 8-hour basic day, and few have an actual 8-hour working day. The opinion prevailed that nothing further should be done at this time to reduce hours of labor or to take other action affecting the length of the working day while present conditions prevail.

J. W. O'Leary in his presidential address foreshadowed the formation of a National Peace Labor Board similar to the National War Labor Board during the war. Referring to the activities of the National Industrial Conference Board he said that the presidents of 23 national industrial associations meet monthly and discuss the general problems of industry. Secretary of Commerce William C. Redfield urged the members of the association and business men generally to avail themselves of the resources of the Department of Commerce, the scientific organization of which employs 1200 scientists and occupies nine buildings with 24 acres of floor space.

United States Chamber of Commerce

Stimulation of domestic and foreign trade by federal enactments, speedy termination of river improvement projects already authorized and provision by Congress for a comprehensive system of waterways with coördination of the services of waterways and railways, prompt return of the railroads to their owners and immediate resumption of construction activities was the import of resolutions adopted by the Chamber of Commerce of the United States in its seventh annual convention at St. Louis, Mo., April 28 to May 1.

While the business men of the country pledged themselves to whole-hearted coöperation with the Government, they declared that the final responsibility before the country in the matter of readjustment rested with the federal authorities. The suggestion was made to consider the revision of all federal laws dealing with business conditions to the end that by proper readjustment of their provisions and of the functions of federal agencies, industry and commerce in the United States may clearly know at all times their powers, rights, limitations and obligations.

It was notable that Director General of Railroads Walker D. Hines and Secretary of Commerce Redfield expressed themselves in accord with some of the most vital principles advocated by the chamber. Mr. Hines recommended the return of the railroads, as did Senator A. B. Cummins, another speaker, while Mr. Redfield favored the abolishment of old-time restrictions on trade and the keener coöperation of the Government with private industrial enterprise.

Chairman Edward N. Hurley of the United States Shipping Board took a most hopeful view of the outlook of the American ship industry. He called attention to the excellent opportunity this country has now to establish on a solid footing the merchant marine which it wants and needs, and felt confident that Congress would pass legislation which would be helpful in accomplishing a permanent and efficient American merchant marine.

American Gear Manufacturers' Association

Standardization of gears was the predominant question of the American Gear Manufacturers' Association at their annual convention in Cleveland, April 14-16. The standardization committee reported that while their work could not be considered as yet in its final form, still the investigations which the committee has performed would eventually lead to remarkable results in obtaining a better standard for gear users and gear manufacturers. The standardization of inspection was also extensively discussed, and it was expected that uniform practice would soon be established, particularly in regard to complaints by users of gears for claims which are in no way the fault of the gear manufacturer.

The composition and physical characteristics of steels for gear making, as well as suggestions in heat treating in this connection, were given in a paper on Gear Steels by J. Herber Parker. Tempered gears have been criticized on account of pitting of tooth surfaces, which was found after limited service. Mr. Parker mentioned several experiences where the condition of pitted surfaces was corrected by reducing the unit tooth pressure. The following are of particular interest:

(1) Misalignment of gears was believed to be the cause of the trouble, thus throwing an excessive load upon only a part of the tooth and vastly increasing the unit tooth pressure. When the gears were properly adjusted and the load properly distributed, pitting disappeared.

(2) A little lower drawing temperature after hardening, which resulted in an increase of about five points in scleroscope hardness, eliminated pitting. The slight increase in hardness was sufficient to enable the gear tooth to withstand the unit tooth pressure put upon it.

(3) Pitting was eliminated by increasing the length of the tooth face. This increase resulted in decreasing the unit tooth pressure to a safe figure. Properly case-hardened gears which have a scleroscope hardness of about 90 will undoubtedly withstand, without pitting, unit tooth pressures which will give trouble in the case of a tempered steel gear which is about 75 scleroscope hard.

Other technical papers presented before the convention were: Worms and Worm Wheels, by G. W. Carlson, and Proper Sizes and Materials for Gears for Tractor Construction, by E. J. Frost.

Air Brake Association

Results of tests and numerous opinions as to the cause of excessive leakage in the auxiliary devices of the locomotive air-brake system and the method that should be used to overcome it were presented at the twenty-sixth annual convention of the Air Brake Association, held at Chicago May 6 to 8.

The Committee on Air Consumption of Locomotive Auxiliary Devices entrusted with this investigation performed both standing and running tests. The standing tests were made on locomotives in roundhouses, and consisted in measuring the amount of air used by the auxiliary devices operated while the locomotives were standing. The running tests were made on freight engines working over the road in service, and consisted of the continuous measurement of air used by the auxiliary devices in operation while the engine was running. A total of 489 individual tests were classified and arranged in the report submitted by the committee. A summary of their principal results is as follows:

1 Auxiliary devices under average conditions were found to use too much air.

2 Conditions frequently exist where compressor capacity may be exceeded by the demands of the auxiliary devices.

3 Some of the data justify the conclusion that auxiliary devices should be operated separately from the air-brake system. On the other hand, some of the data show that with proper maintenance this conclusion might not be warranted.

4 Under some conditions it would not be satisfactory to connect the auxiliary devices to the air-brake system and increase the compressor capacity accordingly, unless the air-brake main reservoir were protected from the consequences of excessive air requirement by the auxiliary devices.

5 Cost-basis data show that better maintenance would be profitable.

6 Standards of performance, including maximum permissible leakage, should be established.

7 Means should be devised for checking and testing the performance of auxiliary devices.

The committee did not consider their work as complete and recommended that their data be further increased by investigations on individual railroads. They concluded by advocating the plan of operating the auxiliary devices at a pressure lower than that carried in the air-brake system main reservoir. This plan would effect a large saving in air used, but would require a separate air-supply reservoir with means provided for controlling the reduced pressure.

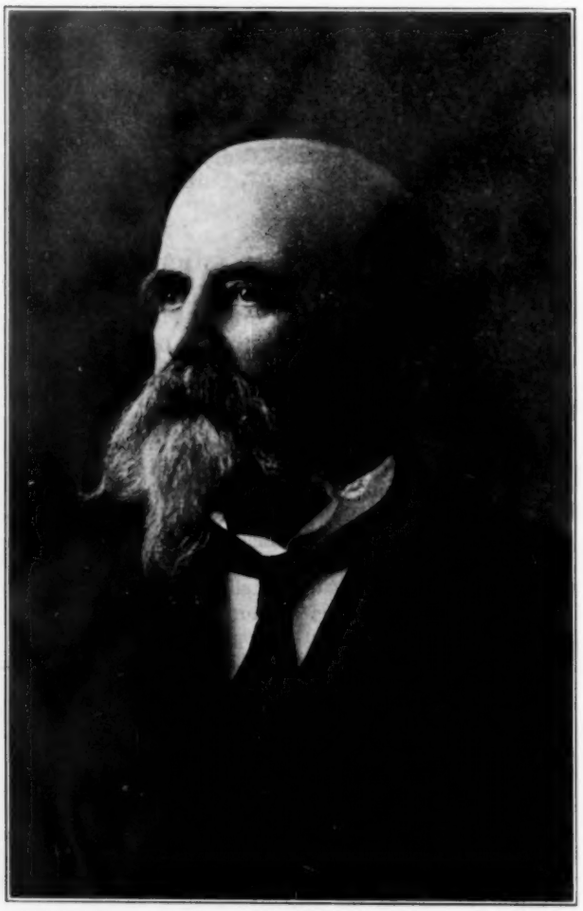
An American Petroleum Institute has been formed with its headquarters in Washington. Its function will be to promote mutual coöperation between representatives of the industry and the departmental or legislative organizations of the Government.

NECROLOGY

CHARLES H. MANNING

Captain Charles H. Manning, honorary member of the Society and for many years prominent in engineering circles in New England, died at Manchester, N. H., on April 1. Captain Manning was born in Baltimore, Md., on June 9, 1844, and received his early education in that city and in Cambridge, Mass., later entering the Lawrence Scientific School of Harvard University, from which he was graduated in 1862 with the degree of B. S.

In February 1863 he was appointed third assistant engineer of the



CHARLES H. MANNING

Navy. His knowledge and comprehensive grasp of scientific matters brought him to the attention of Chief Engineer Isherwood, who assigned him to the making of experiments on superheating steam on the U. S. S. *Adelaide*. He served on the *Adelaide* for two years, when he left her to join the sloop-of-war *Dacotah*. In 1870 Captain Manning was assigned to shore duty as an instructor in the Naval Academy, where he remained five years. During this period he assisted in organizing a course of instruction for cadet engineers at the Academy, and this is considered one of his most valuable achievements.

Captain Manning also served as a member of the first Advisory Board that prescribed the specifications for the so-called "New Navy." Other members of the Board were Rear-Admiral John Rogers and Chief Engineers Benjamin F. Isherwood and Charles H. Loring.

In 1882 Captain Manning retired from active duty in the Navy and was not called into active service again until the Spanish-American War, when he was stationed at the Naval Station at Key West as chief engineer of the repair of the machinery of warships which gathered there. He was commissioned chief engineer on the retired list in February, 1911.

In 1883 Captain Manning became associated as chief engineer with the Amoskeag Manufacturing Company, Manchester, N. H., the largest cotton mills in the world. He had charge of all their power plants and saw the steam power plant grow from one with 870 sq. ft. of grate surface and burning about 400 tons per week, to one with 5,800 sq. ft. of grate surface and capable of burning some 3,000 tons of fuel per week.

The resourcefulness of Captain Manning is well typified by the following incident: In the fall of 1891 a 30-ft. flywheel burst, and being dissatisfied with the metal put into flywheel rims at the time, he designed a new wooden-rimmed wheel of the same diameter with a face of 108 1-4 in. and a thickness of 12 in. This rim was made up of forty rings of ash, and was doubtless the largest wooden-rim wheel in the world.

In addition to his position with the Amoskeag Company, Captain Manning acted as consulting engineer for several other large mills. He was the designer of the well-known Manning boiler and was associated with many pioneer power-plant designs, including one of a 200-hp. horizontal water turbine which at the time of its installation in 1885 was the largest of its kind.

In 1913 Captain Manning retired from the Amoskeag Company and opened offices as a consulting engineer.

As a resident of Manchester, Captain Manning was a very useful citizen. For 28 years he was a member of the Board of Water Commissioners—most of the time its president, and during his incumbency the system was greatly extended and improved. For 18 years he was a member of the school board, where his advice was much respected.

Captain Manning became a member of the Society in 1884 and was made an honorary member in 1913. From 1893 to 1895 he served as manager and from 1895 to 1897 as vice-president of the Society. He was also a member of the Army and Navy Club of New York, the American Society of Naval Engineers, the United States Naval Institute, the American Society of Naval Architects and Marine Engineers, the American Association for the Advancement of Science and the American Association of Cotton Manufacturers.

HARRY H. COOK

Harry H. Cook, chief engineer of the Chapman Valve Manufacturing Co., Indian Orchard, Mass., died on December 15, 1918. Mr. Cook was a 1906 graduate of the Massachusetts Institute of Technology. He was formerly connected with the Coffin Valve Company as chief engineer and with the Providence Engineering Works as sales engineer. Mr. Cook became a junior member of the Society in 1910 and was promoted to full membership in 1918.

JOSEPH FRANZ DIEPENBROCK

Joseph F. Diepenbrock, who until five months ago was in the employ of the Arnold Engineering Co. on important work in connection with Fort Sheridan, died on April 7, 1919. Mr. Diepenbrock was born in Germany on August 28, 1874. He was educated in Essen, attended the Fachschule at Hagen and was graduated from the College Charlottenburg.

He came to the United States in 1901 and became associated with the Dickson Manufacturing Co., Scranton, Pa. From 1902 to 1910 he was employed by the Allis-Chalmers Co., when he resigned to accept a position with the H. R. Worthington Co. He was with the Arnold Engineering Company when his health failed and he was forced to give up active work. Mr. Diepenbrock became a member of the Society in 1912.

MARSHALL TENBROECK DAVIDSON

Marshall T. Davidson, president of the M. T. Davidson Co., Brooklyn, N. Y., died on April 10, 1919. Mr. Davidson was born on February 17, 1837, in Albany, N. Y. He was graduated from the Albany Academy and Polytechnic Institute. During the Civil War he served in the Navy as second assistant engineer and later was promoted to the position of chief engineer in the Revenue Cutter service where he superintended the construction and installation of machinery on vessels for this department. At the close of the War Mr. Davidson engaged in the contracting business and later established the company of which he was president for the construction of the Davidson steam pumps, pumping engines, condensers, evaporators, etc. He was a member of the Society of Naval Architects and Marine Engineers, the Naval Order of the United States and a life member of the Navy League. He became a member of our Society in 1886.

JOSEPH ESREY JOHNSON, JR.

Joseph E. Johnson, Jr., consulting engineer and metallurgist, New York City, died on April 4, 1919. Mr. Johnson was an 1888 graduate of Haverford College, Pa., and received his master's degree in mechanical engineering from Cornell University in 1892.

Mr. Johnson was first employed in the drafting room of the Baldwin Locomotive Works, where he was located for about two years. In 1893 he entered the employ of John E. Sweet of the Straight Line Engine Co. He was next connected with the Solvay Process Co. and in 1894 became assistant to the president of the Ames Iron Co., Oswego, N. Y. In 1895 he became associated with the Longdale Iron Co. as engineer and assistant manager. From 1899 to 1901 he was with the Carnegie Steel Co. when he again returned to the Longdale Iron Co., remaining there until 1906 when he became general manager

of the Princess Furnace Co., Glen Wilton, Va. In 1909 Mr. Johnson was appointed general superintendent of the furnaces and coke ovens of the Republican Iron & Steel Co., Birmingham, Ala., and the following year he became manager of the blast furnace and chemical plant of the Lake Superior Iron & Chemical Co., Ashland, Wis. In 1913 he opened consulting offices in New York City.

Mr. Johnson was a director of the American Institute of Mining and Metallurgical Engineers, member of the American Electrochemical Society, the American Iron and Steel Institute, the British Iron and Steel Institute, the American Institute of Weights and Measures and the American Society for Testing Materials. He became a member of our Society in 1896.

WILLIAM D. KELLEY

William D. Kelley, general superintendent of meters of the Consolidated Gas Company of New York, died on April 12, 1919, at his home in Mount Vernon, N. Y. Mr. Kelley was identified with the gas industry in New York City for forty-one years. He began this business career as a "fitter" but developed rare business qualifications and received frequent advancements so that at the time of his death Mr. Kelley was considered one of the most efficient men in the gas industry.

Mr. Kelley was educated in the public schools of New York City. At the time of his death he was a member of the American Gas Association, the Society of Gas Engineering of New York City and the National Association of Corporation Schools. He became a member of our Society in 1915. Mr. Kelley took a very active part in the proceedings of these organizations and was greatly interested in their work.

His funeral was held on April 15 at Mount Vernon, N. Y., and was attended by many officials and employes of the Consolidated Gas Company of New York.

EDWARD BYRON McKINNEY

Edward B. McKinney, who until his retirement in 1917 was superintendent of power of the New Orleans Railway & Light Co., died on March 30, 1919. Mr. McKinney was born in New York on February 14, 1854, and was educated in the city schools. He served his apprenticeship with the Delamater Iron Works, New York, and afterward served as assistant and later as chief engineer on ocean-going steamers. From 1889 to 1895 he was chief engineer of the Louisiana Electric Light Co., New Orleans, later holding similar positions with the St. Charles St. Railroad Co. and the New Orleans Traction Co. In 1905 he was appointed to the position of superintendent of power of the New Orleans Railway & Light Co. Mr. McKinney became a member of the Society in 1907.

FREDERICK LEO NEELY

Frederick L. Neely, who was engaged on important development work for the E. I. du Pont de Nemours Co., died on January 5, 1919, of influenza. Mr. Neely was born on January 1, 1883, in St. Petersburg, Pa., and was graduated from the Pennsylvania State College in 1904. For five years he was associated with the Allis-Chalmers Co. as superintendent of their erection department and in connection with their sales work. He was also connected for a few years with the Macon Railway & Lighting Co., as superintendent of the public utilities plants of the company. His work with the du Pont Company dealt in great part with the mechanical, experimental and development work on smokeless powder. Mr. Neely became a junior member of the Society in 1909 and was promoted to full membership in 1914.

CHARLES B. RICHARDS

Charles Brinckerhoff Richards, Higgin professor of mechanical engineering in the Sheffield Scientific School, Yale University, for a quarter of a century and since 1909 professor emeritus, died at his home in New Haven, Conn., on Sunday, April 20, 1919, in his eighty-sixth year. Professor Richards was born in Brooklyn on December 23, 1833, and was educated in private schools in that vicinity.

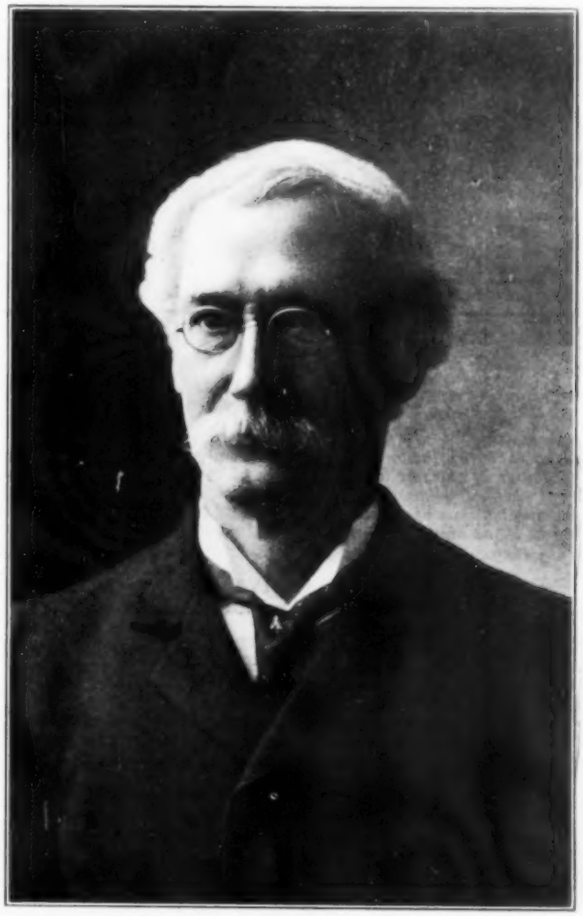
In an article for the *Yale Daily News* Professor Lockwood of Sheffield writes:

"In the death of Professor Charles B. Richards, the mechanical engineering profession loses one of its most prominent members. His early life was spent in Hartford, Conn., at a period when engineering colleges were unknown. He was obliged, therefore, to acquire his theoretical education by the power of personal application, of broad reading and diligent study—this all carried on while busily engaged in practical daily work along manufacturing lines.

"His school was the famous Colt's Armory where his mechanical genius was early recognized. At the age of twenty-seven he opened an office in New York as consulting engineer and at once leaped into wide prominence by his invention of the steam-engine indicator, which made the name of Richards a familiar one wherever steam engines were used. This instrument was produced at a time when the high-speed engine was in its infancy and aided greatly in its development. For this achievement he was made a Chevalier of the Legion of Honor of France, as well as receiving medals from the London Exposition of 1862, the American Institute in 1869, and the French Exposition in 1878.

"With the outbreak of the Civil War Mr. Richards was recalled to Colt's as their assistant superintendent and consulting engineer, where he spent nineteen years of active life. He developed the platform-scale testing machine for testing the strength of metals and was also an authority on the heating and ventilation of buildings, acting as consulting engineer for several large projects, among them the Capitol at Hartford and several of the Yale University buildings. His fertile mind was constantly at work on inventive problems. He was deeply interested in the microscope and made several improvements for which he was granted patents.

"In 1880 Mr. Richards became superintendent of the Southwark Foundry and Machine Company in Philadelphia, manufacturers of the



CHARLES B. RICHARDS

Porter-Allen high-speed engine, marine and other large machinery. Four years later he was invited to become professor of mechanical engineering at the Sheffield Scientific School of Yale University and entered upon the new work of teaching. An inborn taste for study and research undoubtedly led to this choice. For twenty-five years Professor Richards served as the head of the mechanical engineering department, where successive classes were inspired by his friendly spirit and high ideals.

"He was engaged in occasional activities in addition to teaching. He was an American Commissioner at the Paris Exposition in 1889, and edited the report of mechanical appliances. As associate editor he was responsible for the technical terms in two editions of Webster's New International Dictionary.

"In 1909 at the age of seventy-five Professor Richards retired from active work. The esteem of his classes was expressed on this occasion by their presentation to the school of an oil portrait of Professor Richards. This portrait now hangs in the faculty room of the Sheffield Scientific School.

"Professor Richards was a stern disciplinarian and believed in the doctrine of work. Yet his friendly interest in the individual student and his enthusiasm for engineering aroused and maintained a helpful spirit of coöperation with his classes while his great ability and wide experience were recognized and admired."

Professor Richards was a member of the Société Industrielle de

Mulhouse, Alsace, the Society of Naval Architects and Marine Engineers, the Connecticut Academy of Sciences, and a Fellow of the American Academy of Arts and Sciences. He was a charter member of our Society, being present at the organization meeting on April 7, 1880.

DAVID BRAINERD OVIATT

David B. Oviatt, assistant engineer, Board of Water Supply, New York City, died on February 12, 1919. Mr. Oviatt was born in Salem, N. Y., on May 20, 1858. He was graduated from Cornell University in 1887 with the degree of M. E. He was at one time connected with the American Bridge Co., Trenton, N. J., and with the New York Rapid Transit Railroad Co. For several years he also held the position of steel inspector for the New York & Long Island Railroad Co. Mr. Oviatt was appointed to the Board of Water Supply in 1909. He became a member of the Society in 1891.

CARL A. STROM

Carl A. Strom, manager of the Cooke Works of the American Locomotive Co., at Paterson, N. J., died in New York, on March 26, 1919. Mr. Strom was born on August 22, 1868, in Motala, Sweden, and was graduated from the Royal Polytechnic Institute, Stockholm, Sweden, in 1889. He was formerly connected with the Chicago, Omaha and Southwestern Railroad and the Illinois Central. He was also chief mechanical engineer with the Isthmian Canal Commission on the construction of the Panama Canal. Mr. Strom became a member of the Society in 1905.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by June 15 in order to appear in the July issue.

CHANGES OF POSITION

R. L. THOMSEN has become associated with the Terry Steam Turbine Company, Hartford, Conn., in the capacity of sales manager. Mr. Thomsen was previously connected with the Griscom-Russell Company, New York, as manager of the marine department.

ARTHUR C. LINDHOLM, formerly affiliated with the Colt's Patent Fire Arms Company, Hartford, Conn., as mechanical engineer, has assumed the position of general manager of the Franklin Machine and Tool Company, Springfield, Mass.

RAYMOND A. COLE has become connected with the engineering department of the Norton Grinding Company, Worcester, Mass. He was, until recently, engineer in the machine gun department of the Colt's Patent Fire Arms Company, Hartford, Conn.

L. W. HELMREICH, formerly engineer, Electricity, Gas, Heat and Water Department of the Public Service Commission of Missouri, Jefferson City, Mo., has accepted the position of chief engineer of the Corporation Commission of the State of Arkansas.

LESTER B. PATERSON has resigned his position as scheduling engineer and shop accountant, Readville Shops, N. Y., N. H. and H. R. R. Company, and has accepted the position of planning engineer of The Carrie Gyroscopic Corporation, New York.

W. F. ROCKWELL, vice-president in charge of engineering and manufacturing with the Torbensen Axle Company, Cleveland, Ohio, has resigned, effective May 1, to become general manager of The E. B. Hayes Machinery Corporation at Oshkosh, Wis.

EDWARD P. WARNER, formerly aero engineer, Bureau of Aircraft Production, U.S.A., Massachusetts Institute of Technology, Cambridge, Mass., is now employed as chief physicist by the National Advisory Committee for Aeronautics, Research Laboratory, Langley Field, Hampton, Va.

HENRY B. DIRKS, formerly assistant professor of civil engineering, Princeton University, Princeton, N. J., has accepted the position of professor of mechanical engineering, Michigan Agricultural College, East Lansing, Mich.

ADOLF AEBERLI has severed his connection with the Canadian Allis-Chalmers Company, Ltd., Toronto, Ont., Canada, and has become associated with the Hydro-Electric Power Commission of Ontario, Toronto, Canada.

ARTHUR F. WORDEN, until recently connected with the DuPont Engineering Company, Jacksonville, Tenn., in the capacity of fire protection engineer, has entered the service of the American District Telegraph Company, New York, as plant engineer.

J. G. BERGER has become associated with L. K. Comstock and Company, which has recently established a Newark office under the direction of Mr. Berger. This office will engage in the sale of complete industrial and power equipments, as well as construction service. Mr. Berger was formerly connected with the William Gordon Corporation, Philadelphia, Pa., in the capacity of chief engineer.

NORBERT S. ATWELL, formerly in the employ of the Bureau of Aircraft Production, New York, has entered the engineering department of the United States Ball Bearing Manufacturing Company, Chicago, Ill.

HAROLD PRIGOFF, until recently assistant works engineer, Savage Arms Corporation, Utica, N. Y., has become associated with the machinery sales department of the Syracuse Supply Company, Syracuse, N. Y.

S. L. SIMMERING has resigned his position as research associate in the engineering experiment station, University of Illinois, to accept a position as assistant professor of mechanical engineering in the University of Colorado, Boulder, Colo.

WALTER H. HALL has accepted the position of plant engineer, Champion Ignition Company, Flint, Mich. He was formerly connected with the Remington Arms Union Metallic Cartridge Company, Swanton, Vt., in the capacity of works engineer.

ANNOUNCEMENTS

LIEUT. C. W. NICKERSON, U.S.N.R.F., was relieved of all active duty on April 19 and is now associated as mechanical engineer with the North American Dye Corporation, Mt. Vernon, N. Y., manufacturers of Sunset soap dyes.

ALVAN L. GROUT has assumed the duties of plant engineer of the Saco Lowell Shops, Biddeford, Me.

HARRY J. ANGELL, formerly 2d Lieutenant, 26th Engineers, 1st Army Water Supply Service, has returned to the Goulds Manufacturing Company, of New York, in the capacity of sales engineer.

JOHN F. VAUGHAN has resumed his engineering practice. His resignation as district manager for the Emergency Fleet Corporation (New England district) was accepted, to take effect May 1.

DR. WILLIAM P. GERHARD was recently asked by the United States Housing Corporation to serve on a committee composed of four engineers, to investigate and list the plumbing work in several groups of buildings of the Corporation at Bridgeport, Conn.

JAMES L. MYERS, Lieutenant Army Ordnance, Engineering Division, Motor Equipment Section, Washington, D. C., has received his discharge and is now connected with the Cleveland Graphite Bronze Company, Cleveland, Ohio, in the capacity of sales engineer.

CLARENCE BOYLE, JR., secretary of Clarence Boyle, Inc., Chicago, Ill., and formerly district sales manager of the Taylor-Wharton Iron and Steel Company, is changing his residence from Chicago, where the main office of the former company is located, to Atlantic Beach, Fla., to manage the Florida interests of his company.

A. L. MENZIN, industrial engineer, has moved his office from Philadelphia, Pa., to San Francisco, Cal., in which city he was formerly located.

FRANCIS D. AMMEN, for a time identified with the Emergency Fleet Corporation, St. Louis, as production assistant, has formed a partnership with Bruce S. Elliott, for the practice of patent trade-mark and copyright law. They will practice under the firm name of Elliott and Ammen, with offices in St. Louis, Mo.

HENRY C. MEYER, JR., William E. S. Strong and Bassett Jones announce the formation of the firm of Meyer, Strong and Jones, Inc., which will conduct an engineering office for reporting upon and designing power plants and the mechanical and electrical equipment of buildings and industrial establishments. Offices of the firm are at 101 Park Avenue, New York.

RONALD K. MACMASTER, who has served as 1st Lieutenant, Ordnance Department, U.S.R., Gun Division, Production Section, has been promoted to the rank of Captain.

MAX TOLTZ announces the association of Beaver Wade Day, architect, with the Toltz Engineering Company, the name of the company being changed to Toltz, King and Day, Inc., engineers and architects. In addition to the consulting engineering work previously carried on by The Toltz Engineering Company, the reorganized company engineers the general field of architecture, specializing upon industrial and public buildings.

E. REES, of Chicago, Ill., has assumed the duties of chief division lubrication engineer, Sinclair Refining Company, St. Paul, Minn.

HILLARD W. JARRETT has been released from the service as ensign, Naval Aviation, Supervisor of Aircraft Production, and has accepted the position of assistant fuel engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

LIEUT.-COL. JOHN J. SWAN, formerly Personnel Branch, Operation Division, General Staff—after the armistice, Classification Division, Adjutant General's Office, resigned April 7, to become associated with the Prest-O-Lite Company, of Indianapolis, Ind.

S. CLIFFORD MERRILL has become associated with the United States Aluminum Company, Edgewater, N. J., as mechanical engineer.

GEORGE W. CRAVENS has left Government service and will establish himself independently as a consulting engineer with headquarters at Westfield, N. J., and a branch office in New York City. Mr. Cravens was automotive engineer in the Maintenance Division of the Motor Transport Corps, Washington, D. C. Upon leaving the Army he was granted a commission as Major in the Reserve Corps.

GEORGE WILFERT, Captain Ordnance Department, U.S.A., has received his discharge from the service and has accepted a position with the Remington Arms Company, Ilion, N. Y., as consulting engineer on sporting rifles.

RALPH W. E. YARDLEY, recently Captain in the Ordnance Department, in charge of the construction of Inspection Division Proving Grounds during the war and later in charge of the Buildings and Land Section of the Ordnance Department Salvage Board, has resigned his commission and has become associated with Perkins, Fellows and Hamilton, architects.

FRANK P. RHAME, Captain Ordnance Department, U.S.A., has secured his release from military service and has become associated with the Lunkenheimer Company, of Cincinnati, Ohio, in charge of a branch of the sales department which is devoted to power-plant development.

JACOB A. TEACH, Chairman of the Minnesota of the Am. Soc. M. E., 1918-1919, has assumed the duties of contracting engineer, mechanical and structural departments of the Minneapolis Steel and Machinery Company, New York.

JOHN FRICK, for many years in charge of the designing, developing and constructing of the automatic vending machines used by the Horn and Hardart Baking Company, Philadelphia, Pa., has severed his connection as superintendent and designer of the machinery department to enter into business for himself as designer of tools and automatic machines, with offices in Philadelphia, Pa.

COL. H. M. BYLLESBY, president of H. M. Byllesby and Company, has been elected president of the Chicago branch of the National Security League.

Through an error, ARTHUR A. MERRY'S position with the Pratt and Whitney Company, Hartford, Conn., is given in the new issue of the Year Book as assistant works manager. Mr. Merry is associated with the company as production manager.

APPOINTMENTS

WILLIAM D. ENNIS, who has, since his release from military service, been acting professor of mechanical engineering at Columbia University, has been appointed professor in marine engineering in the Post-Graduate Department of the United States Naval Academy.

JOHN H. ROMANN, in charge of the export department of Joseph T. Ryerson and Son, New York, has been appointed the company's representative for France, Belgium, Holland, Switzerland, Italy, Spain and Portugal. Mr. Romann sailed for France in March and will make his permanent home in Paris.

FRED W. FISCHER, recently assistant power superintendent of the DuPont Engineering Company, Nashville, Tenn., has been appointed mechanical superintendent in charge of power, electric and maintenance divisions. This plant was recently taken over by the Ordnance Department and will be known as the Old Hickory Powder Plant.

LIBRARY NOTES AND BOOK REVIEWS

AEROPLANE CONSTRUCTION AND ASSEMBLY. By J. T. King and N. W. Leslie. Press of the William Hood Dunwoody Industrial Institute, Minneapolis. Cloth, 6 x 9 in., 115 pp., 77 illus., 5 pl., $1.50.

This work is intended as a practical manual for mechanics engaged in constructing and rigging airplanes and as a guide to instructors. Airplane assembly, construction and materials and the theory of flight are discussed.

INDUSTRIAL GOODWILL. By John R. Commons. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 8 in., 213 pp., 3 charts, $2.

The author discusses the present-day problems of labor and capital, their relations to each other, and the method of solving them which have been practiced or proposed. The contents: Commodity, Machinery, Goodwill, The Public, Democracy, Solidarity, Theory and Practice, Security, Labor Market, Insurance, Health, the Shop, Education, Loyalty, Personalty, Depression, The World.

IRON AND STEEL. (A pocket encyclopedia.) Including Allied Industries and Sciences. By Hugh P. Tiemann, with an Introduction by Henry Marion Howe. Second edition. McGraw-Hill Book Co., Inc., New York, 1919. Flexible cloth, 4 x 7 in., 514 pp., $4.

In a volume of pocket size the author provides a combination of dictionary encyclopedia and handbook of the iron and steel industries, intended for the metallurgist. The number of terms, and the text also, have been increased about one-half, the chief additions being more extended discussions of heat treatment, physical properties and testing, and of metallographic subjects.

THE MINERAL DEPOSITS OF SOUTH AMERICA. By Benjamin L. Miller and Joseph T. Singewald. First edition. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 598 pp., illus., maps, $5.

An account of the economic geology of the countries of South America, based on an extended visit by the authors in 1915, and a study of the literature. It forms a digest of the available information on the mineral deposits of the continent. Selected bibliographies are appended to each chapter and an adequate index is provided.

MINING PRACTICES. Compiled from the *Engineering and Mining Journal* by the Editorial Staff. McGraw Hill Book Co., Inc., New York, sole selling agents, 1919. Cloth, 9 x 12 in., 105 pp., 56 illus., 11 tables, $1.50.

These articles have been selected to illustrate the range in conditions that must be met in mining operations and to indicate in both a general and a specific way how mining practices are developed.

OFFICE ADMINISTRATION. By J. William Schulze. First edition, second impression. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 5 x 8 in., 295 pp., illus., folded chart, $3.

Written to present a thorough discussion of the principles and methods which underlie efficient and economical management, for use by executives and students of business. It embodies the author's added experience and observation and is intended to replace his earlier book, The American Office.

OFFICE MANAGEMENT. Its Principles and Practice covering Organization, Arrangement, and Operating with Special Consideration of the Employment, Training and Payment of Office Workers. By Lee Galloway. Second printing. The Ronald Press Co., New York, 1919. Flexible leather, 6 x 9 in., 701 pp., 97 illus., 1 pl., $6 (delivered).

This book is intended as an exposition of the basic principles of office administration in its widest sense, with adequate illustration by examples of successful practice.

PHYSICS AND CHEMISTRY OF MINE VENTILATION. A Practical Handbook for Vocational Schools, and for those qualifying for mine foreman and mine inspector certificates. By Joseph J. Walsh.

Second edition. D. Van Nostrand Co., New York, 1918. Cloth, 5 x 8 in., 219 pp., illus., tables, $2.

A textbook of theory and practice for students with limited mathematical knowledge. This edition has been thoroughly revised and a chapter on the sampling and analysis of mine gases has been added.

PRINCIPLES OF RADIOTELEGRAPHY. Prepared in the Extension Division of the University of Wisconsin, by Cyril M. Jansky. First edition. McGraw-Hill Book Co., Inc., New York, 1919. (Engineering Education Series.) Cloth, 6 x 9 in., 242 pp., 179 illus., $2.

A textbook in which the use of mathematical expressions is employed, while an attempt has been made to explain the principles involved so fully that a reader unable to follow the mathematical demonstrations may still acquire some understanding of the subject.

A considerable part of the book is devoted to a discussion of electromagnetic theory and apparatus in order that the student may acquire an intelligent idea of the principles of the operation of radiotelegraphic apparatus.

PUNCHES AND DIES. Layout, Construction and Use. By Frank A. Stanley. First edition. McGraw-Hill Book Co., Inc., New York, 1919. Cloth, 6 x 9 in., 434 pp., 618 illus., $4.

This book has been written to provide die-makers, tool-makers, and tool draftsmen with certain definite information heretofore not available as a whole. Almost ninety per cent of the material, the author states, has not been published before.

QUANTITATIVE ANALYSIS. By Edward G. Mahin. Second edition. McGraw-Hill Book Co., Inc., 1919. Cloth, 5 x 8 in., 605 pp., 122 illus., tables, $3.50.

The author has endeavored to produce a volume that would occupy a position between the complete reference work and the bare outline of laboratory exercises. It covers the material that he wishes to take up in his college courses and at the same time presents a theoretical and practical discussion of the subject. In addition to the presentation of the general subject, a section on the analysis of industrial products and raw materials is included. This edition has been carefully revised and partly rewritten, and new material has been added.

SEWAGE DISPOSAL. By Leonard P. Kinnicutt, C. E. A. Winslow, and R. Winthrop Pratt. Second edition, rewritten. John Wiley & Sons, Inc., New York, 1919. Cloth, 6 x 9 in., 547 pp., 141 illus., 136 tables, $4.

This volume offers a general survey of the problem from the various viewpoints of the chemist, the sanitary biologist and the engineer, with particular reference to the conditions of American practice. The aim has been to discuss rather fully the fundamental principles of chemistry and bacteriology which are involved and to include the more important aspects of the engineering works designed to carry them into operation. This edition has been completely rewritten so as to bring in new data and recent viewpoints on all the topics treated. Several chapters have been much enlarged and several new ones have been added.

STRUCTURAL ENGINEERS' HANDBOOK. Data for the Design and Construction of Steel Bridges and Buildings. By Milo S. Ketchum. Second edition. McGraw-Hill Book Co., Inc., 1918. Flexible cloth, 6 x 9 in., 896 pp., 165 tables, $5.

In preparing the new edition of this working manual for engineers, draftsmen and students, the author has added details for steel windows and doors, data on cement and gypsum tile roofs, solutions for bending moments in mill-building columns and stresses in stiff frames, has rewritten and enlarged the chapter on steel highway bridges, and has corrected all known errors.

ACCESSIONS TO THE LIBRARY

ADVANTAGES OF ROPE TRANSMISSION IN TEXTILE PLANTS. By Frederick S. Greene. Transactions No. 76 of the New England Cotton Manufacturers' Association, *Boston, Mass., 1904.* Gift of Geo. F. Fowler.

AERONAUTICAL ENGINEERING AND AIRPLANE DESIGN. By Lieut. Alexander Klemin. *New York, 1918.*

THE ALKALI INDUSTRY. By J. R. Partington. Industrial Chemistry Series, edited by S. Rideal. *London, 1919.* Purchase.

AN INTERPRETATION OF THE ENGINE FUEL SITUATION. By J. E. Pogue. 1919. To be presented at annual meeting of the Society of Automotive Engineers, Feb. 4-6, 1919. Gift.

ANACONDA REDUCTION WORKS, THE. Anaconda Copper Mining Company, *Anaconda, Mont.*, Jan. 1919. Gift of Mr. Benj. B. Thayer of the Company.

ANNUAIRE DE LA HOUILLE BLANCHE FRANCAISE. By M. Auguste Pawlowski. 2nd year. *Paris, 1918-1919.* Gift.

BOSTON TRANSIT COMMISSION. 15th Annual Report for the year ending June 30, 109. Gift of Geo. F. Fowler.

CHLORINE CONTROL APPARATUS. Wallace & Tiernan Co., Inc. *New York, 1919.* Gift of company.

COMPTES-RENDUS DE L'ATHÉNÉE LOUISIANAIS. Vol. 4, no. 3. Gift of Wm. Beer.

COMUNICACOES DA COMISSAO DO SERVICO GEOLÓGICO DE PORTUGAL. Tom. XII., 1917. *Lisboa.* Gift.

DE BEERS CONSOLIDATED MINES, LTD. 30th Annual Report for year ending June 30, 1918. *Kimberley, So. Africa.* Gift of Company.

DYEING WITH COAL TAR DYESTUFFS. By C. M. Whittaker. Industrial Chemistry Series, edited by S. Rideal. *London, 1919.*

SUGGESTED COLLEGE COURSE ON THE HUMAN SIDE OF ENGINEERING. By Industrial Service Movement, New York.

TRADE CATALOGS

ADAM HILGER, LTD., 75A Camden Road, London, N. W. 1. Abbe Refractometers, with water jacketed prisms. Oct. 1, 1918.
The Hilger Wavelength Spectrometer (Constant deviation type).
The nutting photometer. February, 1919.

AMERICAN STEAM CONVEYOR CORPORATION, 326 West Madison Street, New York. Modern Methods of Ash Disposal. 1919.

ARMSTRONG CORK & INSULATION COMPANY, Pittsburgh, Pa. A Few Service Records.

THE BAYONE CASTING COMPANY, Bayonne, N. J. Monel Metal, for Superheated Steam. 1917. Nickels Castings.

BURT MANUFACTURING COMPANY, Akron, Ohio. Oil filters, exhaust heads and ventilators. 1917.

DELTA-STAR ELECTRIC COMPANY, 2433 Fulton Street, Chicago, Ill. Bulletin No. 34. High Tension Outdoor Universal "Unit Type" Bus Bar and Wiring Supports. Jan. 1919.
Bulletin No. 302. Three-Phase Low Tension Equipment. Jan. 1919.
Addenda Bulletin No. 31A. Unit Type Indoor Bus Supports. Jan. 1919.

THE DEISTER-CONCENTRATOR COMPANY, Fort Wayne, Ind. No. 7 Deister-Overstrom Diagonal Deck Coal Washing Table.

THE ESTERLINE COMPANY, Indianapolis, Ind. The Esterline Graphic. Power factor surveys.

THE J. D. FATE COMPANY, Plymouth, Ohio Catalog No. 4. Bulletin B. Plymouth Gasoline Locomotives.
Catalog 4. Bulletin H. Plymouth Gasoline Locomotives.

FLANNERY BOLT COMPANY, Pittsburgh, Pa. Staybolts (A Bi-Monthly Digest). vol. 6, no. 5. Feb. 1919.

INGERSOLL-RAND COMPANY, 11 Broadway, New York. Equipment for Sugar Factory and Refinery Service.
Form No. 9010. March 1918. The "Sargeant" Ticket Cancelling Box.
Form 9026. June 1918. High Speed-Piston Valve Steam Engine Class "FP" Horizontal Center Crank Type.
Form No. 9123. January 1919. Imperial Tie-Tamping Outfits.
Form 3137. Straight Line Dry Vacuum Pumps.
Form 4333. "Little Tugger" Hoists.
Form 4131. "Jackhamer."
Form 4042. "Jackamer Sinker."
Form 9123. "Imperial."
Form 3039. "Imperial Type Fourteen," Single Stage, Vertical Air Compressors for Belt Drive.
"Imperial" Duplex Dry Vacuum Pumps, Steam and Power Driven, Types "X," "XPV" and "XB."
Form 9026. High Speed, Piston Valve Steam Engine, Class "FP," Horizontal Center Crank Type.
Form 9120. Leyner Oil Furnace, No. 3.
Form 4037. Leyner "Jacksteel" Sharpener Model No. 33.
Form 8014. Drift Bolt Drivers, Types "CC-25" and "CC-251."
Form 3015-2. Electric Driven Portable Air Compressors.
Form 9011. Air Reheaters.

THE JEFFREY MFG. CO., Columbus, Ohio. Catalog No. 245. The Jeffrey Type-A Shredder.
Jeffrey Belt Conveyers. Catalog No. 175.
The Jeffrey Pivoted Bucket Carrier. Catalog No. 210.
Jeffrey Bucket Elevators. Catalog No. 244.
Jeffrey Retarding Conveyers. Catalog No. 232.

KLAXON COMPANY, Industrial Division, New York City. Klaxon Products. Intercommunication and Signal Equipment of Ships. Treatise No. 1.

THE LEEDS & NORTHRUP COMPANY, 4901 Stenton Avenue, Philadelphia, Pa. Checking Thermocouple Pyrometers. Bulletin No. 867-B.

LOCOMOTIVE SUPERHEATER COMPANY, 30 Church Street, New York City. Superheaters for Stationary Power Plants. Bulletin No. T1. 1919.